ONTARIO INSTITUTE OF PEDOLOGY

ANNUAL REPORT

1987

10TH ANNIVERSARY EDITION

Ontario

ontario institute of pedology

89-02196/

ONTARIO INSTITUTE OF PEDOLOGY

ANNUAL REPORT

1987

10TH ANNIVERSARY EDITION

T.P. Hagerty (ed.)

O.I.P. Publication No. 88-6

Photos used in this publication were provided by
Ontario Institute of Pedology and
the Department of
Land Resource Science,
University of Guelph.

❧

Graphics, typesetting and layout
by ***Studio 228,***
Dept. of Land Resource Science,
University of Guelph.

❧

Computer generated map and Original
soil survey map
by Ontario Institute of Pedology

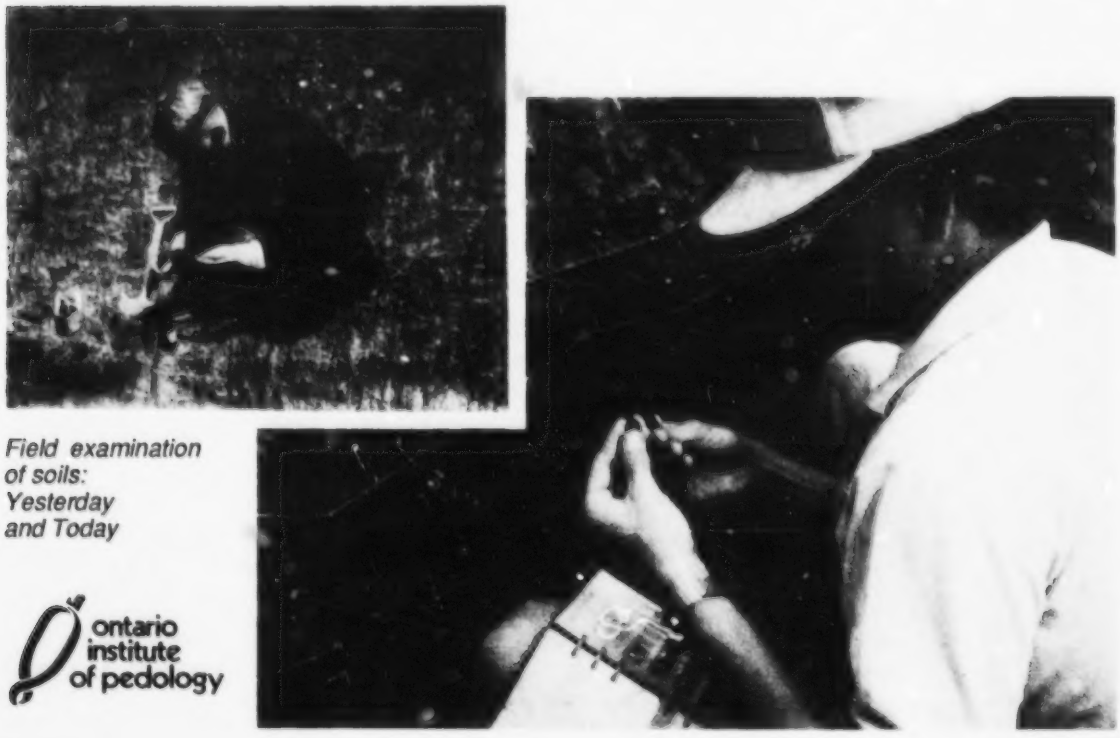
ONTARIO INSTITUTE OF PEDOLOGY

The Ontario Institute of Pedology (OIP) was established in 1977 to coordinate pedological activities in Ontario within the areas of soil inventory, extension and research. This is achieved through the sharing of funding, resources and personnel of its three member agencies, the development of unified goals and plans, and the participation of personnel in joint projects. The Institute operates under a formal agreement between its three members and is comprised of components of the Land Resource Research Centre of Agriculture Canada, Soil and Water Management Branch of the Ontario Ministry of Agriculture and Food (OMAF), and Land Resource Science Department of the University of Guelph.

The main objective of the Institute is to maintain a coordinated soil inventory and interpretation program in Ontario, and to provide soil resource information necessary for making land use decisions at the regional, project and farm level.

In addition, the Institute aims to provide practical training in soils through seminars and field camps for public and private agencies requiring increased knowledge of the use of soil maps and reports, the identification of soil properties in the field, and soil/site interpretive methods.

The research objectives of the Institute focus on soil genesis and classification, soil variability, soil degradation and management, and land classification. The goal of this research is to improve the methodology used in soil survey and increase the effectiveness of interpretations made on soil survey information.



Field examination of soils: Yesterday and Today

ontario institute of pedology

TABLE OF CONTENTS

INTRODUCTION 1

PERSONNEL 3

SOIL SURVEY INVENTORIES
Introduction 5
Brant County 7
Elgin County 7
Kent County 8
Middlesex County 8
Regional Municipality of Niagara 10
Regional Municipality of Ottawa-Carleton 11
Correlation of Existing Soil Information 11

SOIL SURVEY IN ONTARIO - *THEN AND NOW* 15

FOREST SOIL AND ECOSYSTEM WORK
Introduction 20
Forest Ecosystem Classification Programs, Northern Ontario 20
Prime Land Inventory 21
Approaches to the Evaluation of Forest Soil Productivity in Ontario -- Workshop 21
Soil Interpretation and Training Program for Algonquin, Central and Southwestern Regions, 1985-89 21

RESEARCH
Introduction 23
Potential for Soils to Transfer Pesticides to Water Systems in Southern Ontario 23
Nonpoint Source Pollution Problems in Intensive Agricultural Areas of Southern Ontario 24
The Effect of Variable Percentages of Corn Residue on Soil and Water Loss 24
The Effectiveness of Interseeded Red Clover in Silage Corn to Control Soil Erosion 25
Seasonal Variation in Selected Soil Physical, Chemical and Hydrological Properties 25
Soil Aggregate Stability to Rainfall Energy 26
Characterizing the Response of Soils to Cropping Systems 26
Remote Sensing - Land Resource Information Systems 27
Development of a Index of Soil Quality 27
Development of a Rating System for Soil Compaction Susceptibility 28
Water Table - Rainfall and Soil Temperature Observation 28
Characterizing Physical Properties of Potato Producing Soils 29

EXTENSION, TECHNOLOGY TRANSFER AND TECHNICAL ADVISORY SERVICES
Introduction 30
Extension and Technology Transfer Activities in 1987 31

SUPPORT SERVICES
Introduction 33
Computer Operations 33
OIP Soil Characterization Laboratory 33
Cartography Studio 34

1987 PUBLICATIONS
Soil Inventory Projects 35
General Publications 36
Contributions to Refereed Journals 36
List of Papers Presented 36

INTRODUCTION
FROM THE COORDINATING DIRECTOR:

This year marked the 10th anniversary of the Institute. During the past ten years the cooperative efforts of the staff of the three agencies have consistently worked towards the goals of the Institute. These goals have focused on research, soil inventory mapping and report preparation, and to a lesser degree, on extension programs.

During this period, maps and reports were published for Peterborough County, and the Regional Municipalities of Haldimand-Norfolk and Ottawa-Carleton. In addition soil maps were completed and printed for twelve areas in Northern Ontario. The field work has been completed and the maps and reports are in various stages of completion for Brant and Middlesex Counties and the Regional Municipality of Niagara.

These accomplishments have been consistent with earlier plans and the staff are justifiably proud of their collective accomplishments. This period of progress has added greatly to the soil information base for Ontario.

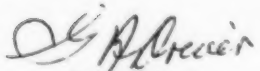
The continued support of the Land Resource Research Centre of Agriculture Canada, the Soil and Water Management Branch of the Ontario Ministry of Agriculture and Food and the Land Resource Science Department of the University of Guelph over this ten year period has made this progress possible.

During 1987, staff of the Institute concentrated their efforts on data analysis and map and report preparation for Brant County and the Regional Municipality of Niagara. The field mapping was concentrated in Elgin county, those townships planned to be surveyed this year were completed and all remaining field mapping is scheduled for completion during the 1988 field season. Detailed soil sampling and description was carried out in Middlesex County for inclusion in the soil report.

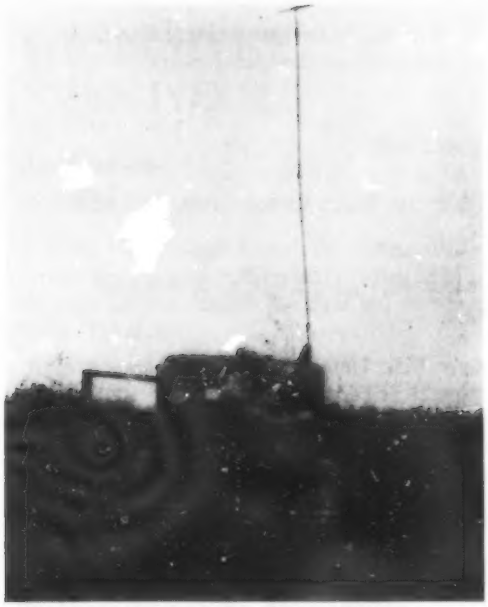
The staff of the Institute are aware of the growing need to help users of soil information learn how to best utilize it in their own applications. In order to better address this need a person was employed this year to coordinate and lead the extension activities. Unfortunately, funding was only available for six months, thus only a modest start was made. Recently announced provincial and federal programs clearly indicate the need for land related information; much of this information is currently available within the Institute. Our programs are becoming more extension oriented to deliver this existing information in a more usable format to all clients.

The use of computer technology plays a very important role within the Institute. Although its prime role is to store field and lab information, much time was spent this year on developing a new computer file and retrieval system. This system will match the requirements for the new geographic information system. These new systems make it possible to electronically derive interpretive maps for specific areas which illustrate soil types, rates of erosion, agricultural capability, etc., thus providing the type of information that will assist the professional person in delivering soil related programs.

This past year marks a full decade of joint Federal/Provincial/University programming within the Institute of Pedology. During these ten years technology has certainly changed; the computer has emerged and multiplied man's capabilities. New applications and technologies are placing increasingly rigorous demands on the information base and will undoubtedly continue to do so in the years to come. The challenge for the Institute is to lead in data analysis and soil related information delivery to the clients. The remainder of this report deals in detail with specific projects. I hope you find the report interesting and informative.



Galen Driver
Co-ordinating Director



Peat bog. Prescott Co. Circa 1930's.

PERSONNEL

ADMINISTRATION:

Coordinating Director - Galen Driver, Program Manager, Soil and Water Management (OMAF), B.Sc. McGill University, M.Sc. Michigan State.

Agriculture Canada, Soil Survey Unit Head - Dr. Cliff Acton, B.S.A., M.Sc. University of Saskatchewan, Ph.D. University of Guelph.

Ontario Ministry of Agriculture and Food, Assistant Program Manager, Provincial Soil Survey Unit - Bob van den Broek, B.Sc., M.Sc. University of Guelph.

University of Guelph, Chairman, Land Resource Science Department - Dr. Bev Kay, B.S.A., M.Sc. University of Guelph, Ph.D. Purdue University.

AGRICULTURE CANADA

Professional Staff:

Keith Jones, B.Sc. University of Victoria, M.Sc. University of British Columbia. Forest Ecologist.

Edward Presant, B.S.A. University of Toronto, M.Sc. Carleton University. Pedologist.

Irene Shelton, B.A. Sir Wilfred Laurier University, M.Sc. University of Guelph. Research Assistant.

Dr. Greg Wall. B.Sc., M.Sc. University of Guelph, Ph.D. Ohio State University. Research Scientist.

Clerical/Technical Staff:

Lena Herron, Clerk Stenographer.

Brian Hohner, Research Technician.

Carolyn Miller, Research Technician.

Sheilah Nolan, B.E.S. University of Waterloo, M.Sc. Purdue University. Soil and Water Conservation Specialist. (commenced duties May 18, 1987, resigned Dec. 31, 1987)

Elizabeth Pringle, B.Sc. (Agr) University of Guelph. Soil and Water Conservation Specialist. (commenced duties April 21, 1987)

ONTARIO MINISTRY OF AGRICULTURE AND FOOD

Professional Staff:

Doug Aspinall, B.Sc. Carleton University, B.Sc. University of Guelph. Pedologist (Seconded to Soil Conservation Program)

Thomas Hagerty, B.A. University of Western Ontario. Pedologist.

Thomas Hilborn, B.Sc. University of Guelph. Pedologist. (resigned April, 1987)

Maxine Kingston, B.A., M.Sc. University of Western Ontario. Pedologist.

Jason Miller, B.A. University of Guelph. Geographic Information System Specialist.

Larry Schut, B.Sc. University of Guelph. Pedologist.

Bill Stevens B.Sc. University of Guelph. Pedologist. (commenced duties May, 1987)

Eric Wilson, B.Sc. University of Guelph. Pedologist.

Technical Staff:

Heather Pearson, B.E.S. University of Waterloo, B.Ed. Brock University. Data Processing Technician. (commenced duties June, 1987)

Karen Mair, B.A. University of Guelph, Digitizer Operator. (commenced duties May, 1987)

UNIVERSITY OF GUELPH

Professional Staff:

Dr. Murray Brown, B.S.A., M.S.A. University of Toronto, Ph.D. Iowa State. Professor, Land Resource Science.

Dr. Trevor Dickinson, B.S.A., B.A.Sc., M.S.A. University of Toronto, Ph.D. Colorado State. Professor, School of Engineering.

Dr. Les Evans, B.Sc. Southampton, Ph.D. Wales. Associate Professor, Land Resource Science.

Cheryl Fitzgibbon, B.A. MacMaster University, M.Sc. University of Saskatchewan. Data Processing Supervisor, Land Resource Science.

Dr. Andy Gordon, B.S.F. New Brunswick, Ph.D. Alaska. R.P.F.. Assistant Professor, Environmental Biology.

Dr. Stewart Hilts, B.A. University of Western Ontario, M.A., Ph.D. University of Toronto. Assistant Professor, Land Resource Science, University School of Rural Planning.

Dr. Gary Kachanoski, B.Sc., M.Sc. University of Saskatchewan, Ph.D. University of California, Davis. Assistant Professor, Land Resource Science.

Dr. Ray McBride, B.Sc., Ph.D. University of Guelph. Assistant Professor, Land Resource Science.

Dr. Murray Miller, B.S.A. University of Toronto, M.S., Ph.D. Purdue University. Professor, Land Resource Science.

Dr. Dick Protz, B.S.A., M.Sc. University of Saskatchewan, Ph.D. Iowa State. Professor, Land Resource Science.

Ted Taylor, B.Sc., M.Sc. (in progress) University of Guelph, Forest Pedologist, Land Resource Science.

Lenore Ross, B.Sc., M.Sc. University of Guelph, Extension Coordinator (6 month pilot position).

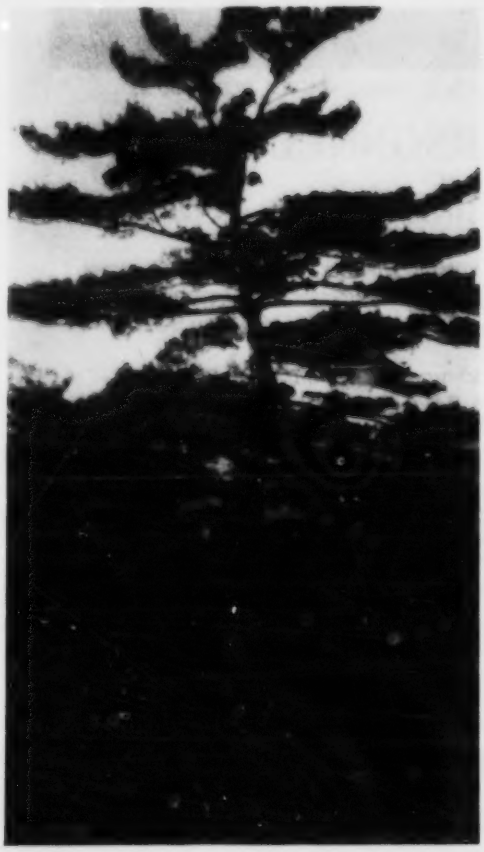
Technical Staff:

Donald E. Irvine, Senior Cartographer, Land Resource Science.

Andy McLennan, Cartographer, Land Resource Science.

Kay Palmer, B.Sc. University of Guelph, Data Analyst, Land Resource Science.

Laurie Stahlbaum, Technician, Land Resource Science.



D.F. Putnam trying to get a good picture of an esker. One mile N.W. of Omemee, Victoria Co. Circa 1930's.

SOIL SURVEY INVENTORIES

Introduction

B. van den Broek

In the 1986 Annual Report, the various phases of a soil survey project were discussed in some detail. Basically there are four distinct phases in any survey project. These are:

- the planning and legend building phase
- the actual mapping phase
- the detailed sampling phase
- the map production and report writing phase

Although all of the above phases are equally important to the soil survey process, there are two phases that should be highlighted since they involve interaction with users of soil information. The first is the planning phase in which the purpose of the survey is defined. The second is the map production and report writing phase which determines the format in which the information will be presented.

The success of any soil inventory project depends for a large part on the planning phase. The Institute's agreement states that the goal of inventory and interpretation is "to assess in cooperation with user groups the suitability of land for man's use in agriculture, forestry, rural planning and other related uses". The fact that soil inventories are being conducted for a number of user groups with a variety of interests and demands is very important. The potential applications and user groups of the information must be identified and priorized since their needs will determine the level of detail of the survey. Since soil information is used by a wide variety of groups, it is often the case that their needs are in conflict with one another. As a result, the publication scale usually must find a middle ground which will present some detail while still being general enough to provide an overview. Time and the manpower available to undertake an inventory project is another critical factor in determining the intensity or detail of a survey.

The format in which the information is presented is also very important. Over the past decade we have seen the soil report change from a single thin volume with a colored soil map in the back to a two volume report often with multiple maps covering the area. The first volume of the modern soil report contains the various map unit descriptions and the soil interpretations. The amount of detailed analytical information presented in recent reports has increased to the point where it has required a second volume of its own.

There are usually a series of publications released by the Institute during the course of a survey project which eventually culminate in the final report and maps. A survey project can take several years to undertake and publishing the information in a preliminary form as it is completed achieves two things. First, it fulfills the immediate needs of the user groups, and second, it provides an opportunity for the users of the information to give feedback on the content and format of the information before it is finalized. In chronological order the users can anticipate to receive the following publications:

1. The preliminary soil maps

After each field season (lasting from May through November), the pedologist will review the summer's field work and draft a map that closely resembles the future final map. Depending on the size of the area and the level of detail at which the soils have been mapped, this will take several months to complete. Although the soil lines in most cases closely approximate the soil lines which will appear on the final soil map, the map unit symbol (the code identifying the soil on the map) may change from the preliminary to final map. These changes are based on legend revisions made as more complete data becomes available as the survey progresses.

The preliminary maps usually include some related background information on the survey area along the map border. The preliminary maps are available as blue prints and the information on the map is hand lettered. Copies of these preliminary maps can be obtained free of charge from the Institute in Guelph. Preliminary maps provide the user with a first approximation as to what the final map(s) will look like.

In order to find out what information has been published in a preliminary form for the current survey projects, the user is advised to contact the party leaders of specific survey projects as detailed in this report.

2. Special publication bulletins

The significance to the user of a soil map, by itself, is limited to showing the distribution pattern of the various soils. Usually, the user also requires some sort of interpretation of how the properties of mapped soils affect the general agricultural capability of mapped areas, or the suitability of these areas to specialty crop production. Thus, as soon as the first preliminary map is released, steps are undertaken to develop the necessary interpretations for the soil units represented on the

preliminary soil maps.

The most widely used interpretive system is the Canada Land Inventory (CLI) ratings for agriculture. The preliminary CLI ratings are published in a separate OIP publication to accompany the maps. Additional interpretations for specialty crop suitability may also be published. Again this information can be obtained free of charge from the Institute of Pedology.

These publications are PROJECT SPECIFIC and should not be used for other areas or counties in the province.

3. The final soil maps

At the end of each survey project, the final maps are drafted. Map finalization involves incorporating any revisions or improvements required on the maps before they are sent to be printed. This is usually a very rigorous review and editing process on the maps. Often the map unit symbols appearing on the preliminary maps have to be converted into a symbol format that conforms to the standards that have been set for the province. Finalization of map symbols is usually the last stage of finalizing the map legend.

Soil maps at a scale of 1:50,000 or smaller are printed in colour, maps at a scale of 1:25,000 or larger are printed in monochrome. Before the maps are sent to Agriculture Canada in Ottawa for printing, they are digitized and the necessary computer data files to accompany the map(s) are created. Once in Ottawa the maps are prepared for the final printing. This includes the preparation of an up-dated base map, production of colour separations, etc. Finally, the maps are printed by the Department of Energy, Mines, and Resources in Ottawa, folded, and mailed back to the Institute where they are merged with the final soil report. The final soil maps can only be purchased (in combination with the soil report) from the Consumer Information Centre of the Ontario Ministry of Agriculture and Food in Toronto.

4. The final soil report

Once the soil data has been analyzed, all the soil maps have been drafted, and all the interpretations made, a survey project enters the report writing stage.

Volume One of the modern soil report contains the general information about the area (geographical location and the natural setting), the soil key, the map unit descriptions (general soil and landscape characteristics), and the various soil interpretations. The soil interpretations, which appear in the final report, are finalized versions of the preliminary interpretations discussed above. In the most recent reports, these soil interpretations have included CLI for Agriculture, suitability ratings for specialty crops, susceptibility to soil erosion, and the suitability for tree species (woodlot improvement).

Volume Two of the soil report contains analytical data for the soil series that are represented on the map. This analytical data is comprised of detailed profile descriptions and lab data for representative soils in the area. It also contains a statistical summary of all sampled sites for each soil association or series on the map. This summary describes the central tendency, range and variability of given soil properties. Where applicable, one can also find information regarding physical properties of the soils which may be useful for engineering interpretations. Volume two is geared to those users who want detailed information on the chemical and physical characteristics of mapped soils.

The process of writing and editing a soil report is a lengthy and complex task and may take up to a full year. Once the report has been edited and corrected it will go to the printer. The final report and maps can be purchased from the Consumer Information Centre of the Ontario Ministry of Agriculture and Food. To find out what soil information is available from this Centre, please consult the brochure "Index of Soil Surveys In Ontario", copies of which can be obtained free of charge from the Institute or the OMAF offices in each county.

As can be seen from the above discussion, a soil survey is a complex undertaking which progresses through a series of logical stages or steps. While the field mapping stage is possibly the most highly visible, the job is far from finished when the field work is completed. Often the map production and report writing phase of a project can require as much time as the active field stages.

In the following sections, the user will find more detailed information regarding the various soil inventory projects that are currently being undertaken by the Institute.

Pit in Bellefontaine loam soil, between Guelph and Puslinch Lake. Circa 1940's.

Brant County

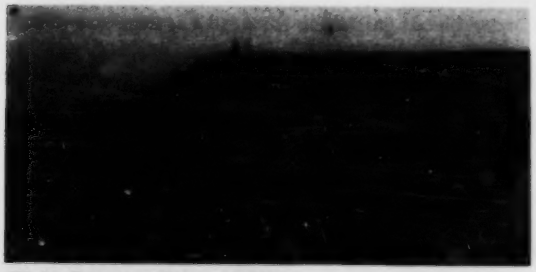
C. J. Acton

During the past year, three preliminary maps have been prepared for South Dumfries, Burford and Brantford-Oakland townships. These maps, as shown on the accompanying index map, will be available on request from the Institute in blue-print form pending the printing of the final maps. Some preliminary interpretive information on agricultural capability and suitability of mapped soils for specialty crops is available, on request, from the project leader

The soils, landforms and topography of Brant County encompass a very wide range of conditions. The soils developed on the strongly rolling and hummocky morainal landforms in South Dumfries township provide sharp contrast to those on the nearly level sand plains in Burford township, or on similarly level clay plains of Onondaga and Tuscarora townships.

To a very large degree, soil and topography are the determining factors in land use in the county. The hummocky, morainal areas, with their characteristic steep slopes and stony soils, are characterized by non-intensive agriculture. In a similar way, soil conditions with limitations of drainage and structure contribute to low intensity agricultural use in much of the clay plains of Onondaga and Tuscarora townships. The most intensively used agricultural areas in the county are the sandy and loamy textured glacial till and lacustrine soils which predominate throughout much of Burford, Brantford, Oakland, and parts of South Dumfries townships. For the most part, their good drainage, gentle to moderate slopes, and ease of tillage are amenable to a broad range of crops.

The soil survey report which is being prepared for Brant County will relate the physical and chemical properties of the soils mapped in the areas discussed above to their agricultural capability for general field crops, and their suitability for various specialty crops. This aspect of the project is presently at the data compilation stage.



Elgin County. Circa 1930's.

Brant County map areas

Elgin County

L. W. Schut

In the Spring of 1987, it was decided that Elgin County would be mapped at a scale of 1:50,000. Based on an assessment of user needs undertaken in 1986, soil information provided at this scale would be acceptable for most potential users. In addition, it would also result in a shorter completion time since survey procedures for this scale are less intensive than those necessary for a larger scale, i.e. 1:25,000.

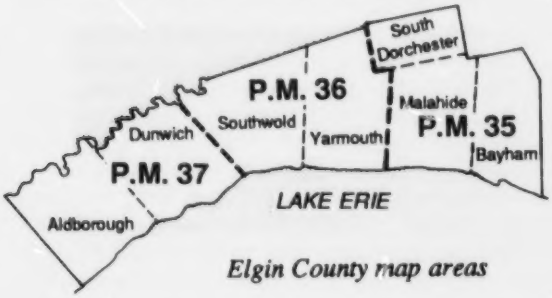
Map coverage of the County will be available on three map sheets as shown on the accompanying map. During the 1987 field season, mapping was completed in Bayham, South Dorchester, Malahide, Southwold and Yarmouth Townships. After completion of this field mapping, the remainder of 1987 was devoted to final checking and editing of the information gathered toward the preparation of preliminary maps, two of which will be published in 1988. Preliminary Map 35 includes Bayham, South Dorchester, and Malahide Townships, and is titled "Preliminary Soils of Elgin County (Eastern Portion)". Preliminary Map 36 includes Southwold and Yarmouth Townships, and is titled "Preliminary Soils of Elgin County (Central Portion)".

Elgin County is primarily comprised of rural areas in which intensive agricultural land uses of various types predominate. Many soils in the County rank among the best in the province, either for their agricultural capability in general, their suitability for specialty crops (i.e. tobacco), or both. Detailed chemical and physical descriptions for the soils of the County, their capability/suitability for various uses, and a precise map showing their location have previously been unavailable. All of this information, however, is needed

in order to make appropriate land use decisions such as what crops to grow, or what conservation measures are required. The main objective of the survey is to provide this type of information.

A second objective of the survey is to better define the soils with lower agricultural capability which occur in the County. It has been estimated that ninety percent of the soils have a Canada Land Inventory (CLI) rating of Class 4 or better for agriculture (ARDA Report No, 8, 1975). For land use decisions pertaining to non-agricultural uses, i.e. urban development, it is very important that the type and location of lower capability soils be well defined so that non-agricultural land uses can be directed to these soil areas. A method to highlight these soil areas as much as possible has been incorporated into the mapping system currently being used in the County.

Conservation measures to limit soil degradation are important considerations in land management decisions. They become even more important in areas such as Elgin County where agricultural land use is very intensive. With this in mind, a third objective of the survey is to provide pertinent information with regard to the susceptibility of soils in the County to various types of degradation. This information will assist land managers in determining appropriate soil conservation measures which should be employed.

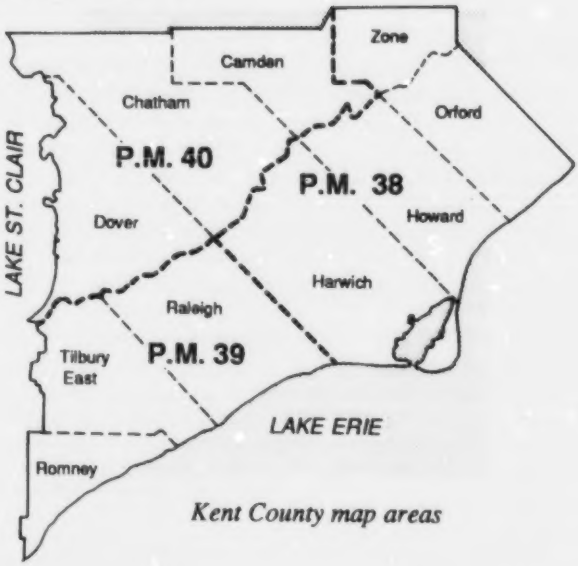


Elgin County map areas

Kent County

E. A. Wilson

A resurvey of the soils of Kent County is scheduled to begin in 1988. The objective is to provide more detailed soil resource information and accompanying interpretations than presently exist within the old 1:126,720 (1/2 inch to the mile) scale map published in 1936. Field endeavors in 1988 will concentrate on development of a soil legend. Actual field mapping of the soils is to begin in 1989 and is scheduled for completion by November of 1990. Preliminary soil map and interpretive information will be published following both the 1989 and 1990 field seasons. Final maps and the report are scheduled for publication in late 1992 or early 1993.



Kent County map areas

Middlesex County

T. P. Hagerty

Middlesex County was originally mapped in the 1920's at a scale of 1:126,720 with the final map published in 1931. While this map was excellent for identifying the major soil types in the County it was at much too general a scale for today's purposes. As a result the county is now being re-mapped at a more detailed scale of 1:50,000. At this new scale, coverage for the entire county will be available on three map sheets.

The field portion of the Middlesex County Project is now complete. With the publication of Preliminary Maps 33 and 34 in 1987, soil information is currently available for all three map areas in a preliminary form. Preliminary agricultural capability ratings to accompany the published preliminary maps were also published in 1987. The interpretive information is in a tabular form and can be applied to symbols appearing on the soil maps.

All preliminary maps and interpretations for Middlesex County are available from the Institute's office in Guelph.

The 1987 field season in Middlesex was spent locating and sampling typical soil sites for the majority of the soil associations listed on the Middlesex soil legend. This process involves a statistical analysis of the soil data collected during the survey. The aim of this analysis is to identify central tendencies for soil

properties in each association and to construct a conceptual model of a typical profile. This conceptual model or typical profile is then used to help identify previously sampled sites which best exhibit the soil association's central tendencies for all the measured variables.

Final site selection is based on a field inspection. If the site is suitable, a pit is dug, a detailed description done and the profile sampled for detailed analysis. This process provides information on the structural characteristics of the soil, bulk density, moisture retention, and hydraulic conductivity. This information is used in the interpretive process and is reported in the second volume of the soil report.

In addition, bulk samples are taken at each of these sites and sent to the Ministry of Transportation and Communication lab for analysis of engineering properties. This information will also be included in the second volume of the Middlesex Soil Report when published.

Additional field work in 1987 included the field checking and sampling of organic soil deposits in the Middlesex County area. On the preliminary maps no effort was made to characterize the organic soils in the County and they were simply mapped as undifferentiated organic soils. The sampling undertaken in 1987 is part of a separate legend building exercise for these specialized soils. Once this section of the legend is complete, organic soils will be named and characterized as part of the preparation of the final maps.

Since the end of the field season in late November efforts have been focused on preparing final maps for publication with the Middlesex Soil Report.

Some project related extension activities were also undertaken in Middlesex in 1987. In cooperation with the OIP Extension Coordinator, a talk was given introducing the new Middlesex preliminary soil maps at a soil conservation day held in Middlesex on July 8, 1987. In addition, a large soil pit was dug in the sandy Plainfield Association soil of the farm. The exposed profile was used as a basis for discussing the different moisture-holding capacities of the sandy soil associations mapped in the Middlesex County area and the ultimate implications this has for rating agricultural capability. Much interest was generated by the discussion.

Feedback from a planning consultant working for several of the townships in Middlesex County revealed the need for some additional extension activities with the planning community in the Middlesex County area. A meeting was held to address some of the most immediate concerns relating to the application of the new soil information to the development of a new official plan in one township, and to a planning study of the London urban fringe in another township.

A more general workshop has been scheduled for early in 1988 through the OMAF Foodland Preservation Branch land use specialist for the area, in order to introduce the new information to the members of the planning community and to answer any questions they may have. Planners in the area are very interested in this as the new maps and interpretations have very real implications for the planning process.

The Middlesex County Project is now entering its final stage. Over the next year the maps will be finalized, the data analyzed and writing of the report will commence.

Middlesex County map areas

Middlesex County cornfield. Circa 1930's.

Regional Municipality of Niagara

M. S. Kingston

During 1987 significant progress was made on the soil survey of the Niagara Region. Two additional preliminary interpretive bulletins were prepared in consultation with crop experts from the Region and published in 1987. Following the completion of these two preliminary bulletins the emphasis of the project shifted to producing the final soil maps and the final soil report.

Field checking was completed for all the final maps and four of the seven maps were prepared for publication. The remaining three maps will be ready for publication in 1988. At that time prints of the maps will be available on request from the Institute. Preliminary maps should no longer be used as they do not represent the most up to date information on the soils of the Region.

The main difference between the final and preliminary Niagara maps is that soils on the final maps are named rather than being designated numerically. Also, the soil proportions and slopes are depicted somewhat differently than on the preliminary maps. In addition, some soil boundaries have been changed, and new ones added to reflect new soil information obtained since the soil mapping was done for the preliminary maps. The location and names of the final maps are shown on the index map below.

Some progress was made on the soil report. It will consist of two volumes, the content of which will follow the general format which has been established for the Institute's publications. A significant portion of Volume One will consist of tables which will rate the soils for their capability and suitability for various crops, susceptibility to erosion, and suitability for forest tree species. Toward this end the preliminary capability and suitability ratings were finalized and updated to correlate with the new soil names on the final maps. The tables were prepared for publication as interpretive bulletins and will be available on request with the final soil maps early in 1988. The titles of these bulletins are:

OIP Publication No. 87-6. Updated Agricultural Soil Capabilities for Common Field Crops in the Niagara Region.

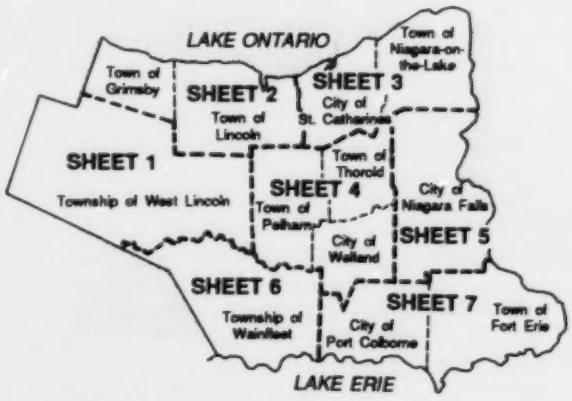
OIP Publication No. 87-7. Updated Soil Suitability Ratings for Tree Fruits, Grapes and Small Fruits in the Niagara Region.

OIP Publication No. 87-9. Updated Soil Suitability Ratings for Soybeans, White Beans, Spring Canola and Winter Rapeseed in the Niagara Region.

OIP Publication No. 87-10. Updated Soil Suitability Ratings for Vegetable Crops in the Niagara Region.

In Publication No. 87-6 the capabilities of the soil to produce crops such as corn, small grains and forages are described using the guidelines outlined in the Canada Land Inventory Capability for Agriculture. The latter publications (87-7, 87-9, 87-10) contain suitability ratings for each soil for those crops not covered by the CLI. A seven class system is used ranging from G (good), F-G (fair to good), F (fair), P-F (poor to fair), P (poor), VP (very poor), and U (unsuitable). The ratings were designed to characterize the suitability of the soils in their natural state. The improvements to the ratings which can be made by the use of tile drainage and/or irrigation are given in the interpretive tables.

Considerable work was done in 1987 on Volume Two of the Niagara Soil Report. This volume contains detailed soil descriptions and analytical data, and is expected to be completed in 1988.



Regional Municipality of Niagara
Final map areas

Regional Municipality of Ottawa - Carleton

E. A. Wilson

The final soil report and maps for the Regional Municipality of Ottawa-Carleton were published in December, 1987. This final report replaces the preliminary maps and interpretations which were made available as the survey progressed.

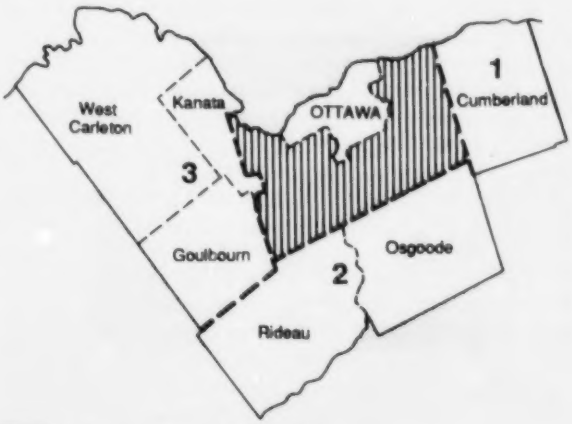
The soil report, comprising two volumes, and the three soil maps address the broad spectrum of different soil types present in the Regional Municipality. The soils in this physiographically diverse region range from fertile, though somewhat poorly drained, clayey and loamy materials of marine and lacustrine origin, to loamy and sandy materials of glacial origin which are of variable quality due to variation in surface stoniness and topography, to shallow soils of low quality associated with Precambrian and Paleozoic rocklands. To classify the soils present, thirty soil associations were identified. Each soil association represents a group of soils of similar texture and parent material. The soil associations are further classified into a number of soil landscape units, which represent soils of similar natural drainage conditions and topography. Soil delineations on the maps represent areas where one soil landscape unit or a combination of two soil landscape units have been identified.

The soil report includes three sets of interpretations. These are: soil capability for common field crops (based on the Canada Land Inventory System), potential susceptibility to damage from water erosion (based on the Universal Soil Loss Equation), and soil suitabilities for eight common forest plantation tree species. Each of these interpretive sets provide a rating for each respective soil landscape unit. This enables the interpretive ratings to be applied to each soil delineation on the maps.

The soil information from this updated survey has already been utilized in the region in several ways. Foremost amongst these was the use of preliminary maps and soil capability ratings as a resource reference base in the recent review and revision of the Regional Municipality's official plan. The new information also serves as a reference in the administration of the Foodland Guidelines by staff of the Foodland Preservation Branch of OMAF. A third use of note has been in the assessment of property values for rural property tax assessment.

The new maps and reports have numerous other potential uses. One of these may be in the local administration of OMAF's new Land Stewardship Program. The maps and report can provide information regarding general soil texture, locations of areas of high soil erosion potential, and recommendations regarding suitable forest plantation tree species for land to be retired from cultivation.

Copies of the soil report, including the three soil maps, are available from the Consumer Information Centre, OMAF, under the title: "The Soils of the Regional Municipality of Ottawa-Carleton (excluding the Ottawa Urban Fringe)", Report No. 58 of the Ontario Institute of Pedology. The two volumes of the report are available as a package or can be purchased separately. Volume One includes the three soil maps (scale 1:50,000) and contains background information on the area, descriptions of the soil associations and soil landscape units, and the three sets of soil interpretations. Volume Two contains descriptions and laboratory analysis data for typical soil profiles of the area.



Ottawa-Carleton final map areas

Correlation of Existing Soil Information

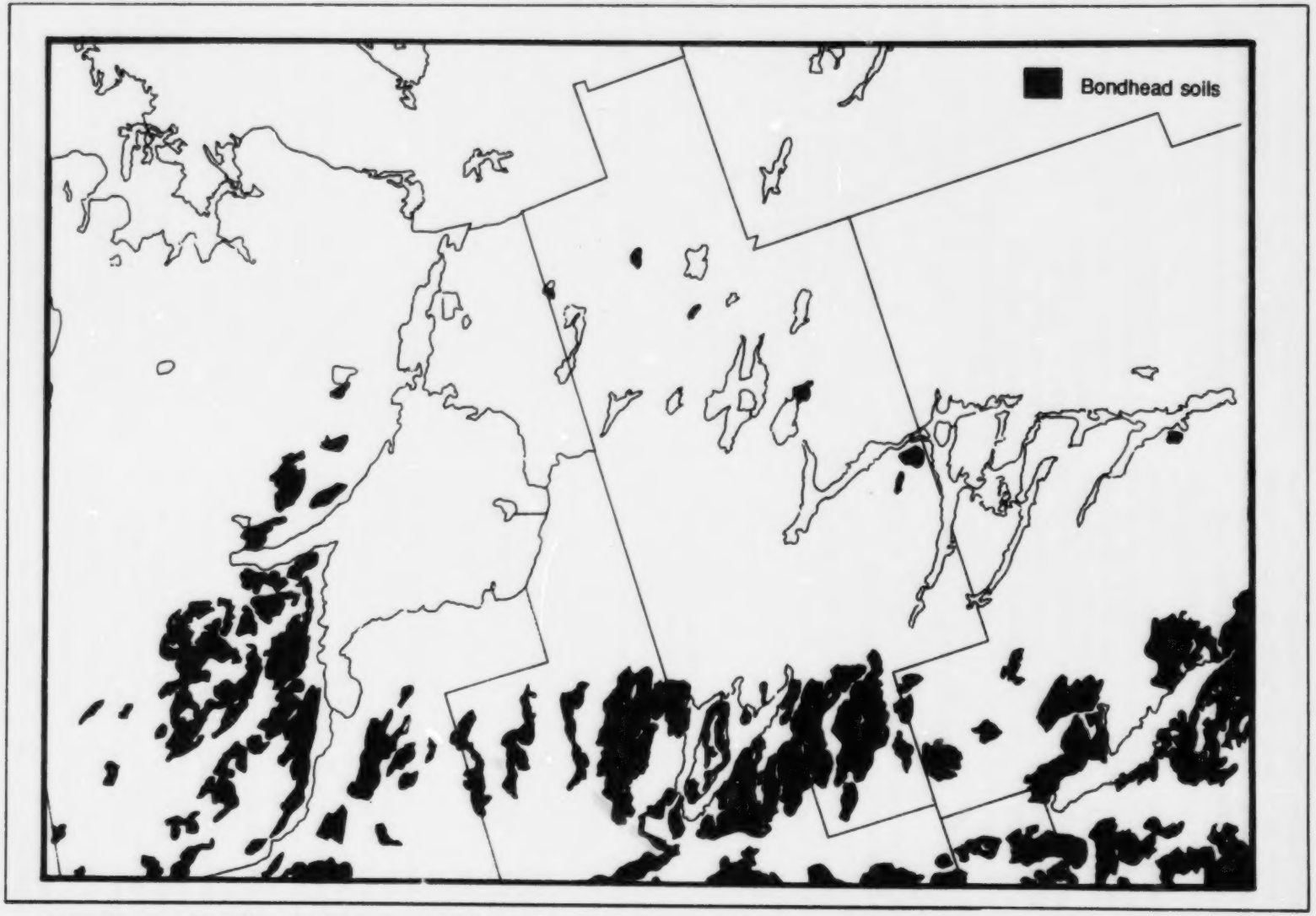
B. van den Broek

In the 1986 Annual Report, soil correlation was mentioned as being of great importance to the Ontario Institute of Pedology (OIP). One of the prime reasons for a soil correlation file(s) is the ability to compare newly acquired soil information with existing information, thus promoting consistency in characterizing and naming soils. Although this is the prime reason for soil correlation, it is not the only reason.

The current emphasis in the OIP is not only on producing soil maps but also on interpreting the information in a way that satisfies the needs of the various users. With the acquisition of an improved geographic

DISTRIBUTION PATTERN OF BONDHEAD SOILS IN CENTRAL ONTARIO

Scale 1:750000 NTS-31D



Computer map files allow the large scale distribution of named soils to be plotted on the Geographic Information System. This can become a powerful tool for correlation purposes.

information system (GIS) this past year, the Institute is exploring the potential of publishing computer derived interpretive maps. This would mean that, in addition to publishing a conventional soil report and map, it would be possible to produce a derived map that will specifically emphasize particular uses and/or interpretations that are tailored to the need(s) of the user. In order to make this possible, it is necessary to have a reliable data base (consistent across the province) that will form the basis for the soil interpretations.

Over the past two years, significant progress has been made on the cataloguing of all the existing soils information. In 1987 the emphasis was mainly on editing, cross tabulating, and upgrading the information already contained in the different computer files. One of the major difficulties encountered in the editing process is that one has to compare soils information that was collected over a number of decades and at various levels of detail (varying soil survey intensity levels). The problem is compounded by the fact that most of the older soil reports have very limited information as far as a soil data base (i.e. particle size analysis, organic matter content, pH, etc.) is concerned, and all that is available to compare with are the individual soil descriptions themselves. Specifically, the soil information that was collected prior to 1970, comprising about seventy five percent of Southern Ontario, lacks the necessary soil data that will allow for the comparison of the various soils.

To date the following computer files have been developed for cataloguing the soils information:

1. A SOIL NAMES file for all of Ontario. This file lists approximately 650 soil names (excluding those for organic soils) currently in use in Ontario. This file contains information regarding the soil name, the CanSIS abbreviation (three letter code), the mode of deposition, and whether this soil name is used in southern or northern Ontario.

2. Parallel to the SOIL NAMES file is the SOIL ASSOCIATION file. This file provides information regarding the catenary members of any particular soil in southern and northern Ontario.

3. The third file is a SOIL CORRELATION file that provides details (in a descriptive form) regarding the soil profile characteristics for each of the soils in Southern Ontario. Information including natural drainage, stoniness, textural ranges, reaction, approximate depth of solum, approximate depth to soil discontinuities, etc. can be found in this file.

4. For those soils for which there exists analytical data, a fourth file has been created, called the CHEM-SOIL file. This file contains the detailed profile descriptions as well as some of the analytical data (i.e. particle size, pH, organic matter, and carbonates).

Work is progressing on linking all the above files by means of a user friendly program that will allow the user to integrate the files for any particulars regarding any soil in Ontario.

In addition to the above files there are a number of other files that are currently being developed. These files are intended to be available in a "hard" copy only. These files include:

1. Standardized EXTENDED SOIL LEGEND I for all the counties in Southern Ontario. In this case each county legend was transformed into a standard file format. It will provide the user with information such as the name of the soil, mode of deposition, map unit symbol, dominant surface texture(s), soil phases, a brief description of the solum, natural drainage, general topography, surface stoniness content, and special remarks. The information presented runs parallel to the information in the first two files but are county specific.

2. A second (EXTENDED SOILS LEGEND II) file is under development. This file will complement the information that is presented in the EXTENDED SOILS LEGEND I file and contains general information regarding the movement of water through the soil as well as across the land, soil erosion problems, suitability for general field crops, suitability for specialty crops, and limiting soil factors that may inhibit plant growth and development, etc. This information is obtained from that which is reported in the various soil reports.

3. A third file in this series is a computer map file that will show the distribution of the various soils across the province (refer to accompanying Map). This file has been developed for Southern Ontario but will require editing to make it complete. The conversion to the new GIS system will necessitate making these map files compatible with the new system.

All the above data files are yet in a developmental stage and not ready to be distributed amongst the various users. More editorial work and refinements of the system have yet to be made before any of the information can be released.

SUMMARY OF SOIL SURVEY COVERAGE

County/Area/ NTS Reference	Report No.	Date	Scale	No. of Maps	Cost	Available From
Brant	55	in prep	1:25,000	4	No charge	OIP[1]
Blind River-Sault Ste Marie (41J, 41K)[2]	50	1983	1:250,000 1:50,000	1 12	1.00 1.00/map	CIC[3] CIC
Bruce[4]	16	1954	1:63,360[5]	2	1.00/map	CIC
Chapleau-Foleyet (41O,42B)	61	1986	1:250,000	2	2.00	CIC
Dufferin	38	1963	1:63,360	1	2.00	CIC
Dundas	14	1952	1:63,360	1	2.00	CIC
Durham[4]	9	1948	1:126,720	1	1.00	CIC
Elgin	63	in prep	1:50,000	3	No charge	OIP
Essex[4]	11	1949	1:63,360	1	1.00	CIC
Fort Frances-Rainy River (52C, 52D)[2]	51	1985 1986	1:250,000 1:50,000	1 5	1.00 1.00/map	CIC CIC
Frontenac	39	1963	1:63,360	2	2.00	CIC
Glengarry[4]	24	1957	1:63,360	1	1.00	CIC
Gogama (41P)[2]	59	1987 1987	1:250,000 1:50,000	1 2	1.00 1.00/map	CIC CIC
Grenville	12	1949	1:63,360	1	2.00	CIC
Grey[4]	17	1954	1:63,360	2	1.00/map	CIC
Haldimand-Norfolk	57	1984 1984 1985	 1:25,000 1:100,000	 13 1	2vol/5.00 ea 1.00/map 1.00	CIC CIC CIC
Halton	43	1971	1:63,360	1	2.00	CIC
Hastings[4]	27	1962	1:63,360	2	1.00/map	CIC
Huron[4]	13	1952	1:63,360	2	1.00/map	CIC
Kenora-Dryden-Pointe-du-Bois (52E, 52F, 52L)[2]	52	in prep in prep	1:250,000 1:50,000	2 4	No charge No charge	OIP OIP
Kent[2]	3	1930	1:126,720	1	1.00	CIC
Lambton[4]	22	1957	1:63,360	1	1.00	CIC
Lanark	40	1967	1:63,360	2	2.00	CIC
Leeds	41	1968	1:63,360	2	2.00	CIC
Lennox-Addington	36	1961	1:63,360	2	2.00	CIC
Manitoulin Island	26	1959	1:63,360	2	2.00	CIC
Middlesex	56	in prep	1:50,000	3	No charge	OIP
Niagara	60	in prep	1:25,000	7	No charge	OIP

County/Area/ NTS Reference	Report No.	Date	Scale	No. of Maps	Cost	Available From
North Bay (31L)[2]	54	1987 1987	1:250,000 1:50,000	1 7	1.00 1.00/map	CIC CIC
Northumberland	42	1976	1:63,360	1	2.00	CIC
Ontario[4]	23	1956	1:63,360	2	1.00/map	CIC
Ottawa-Carleton	58	1987	1:50,000	3	7.50	CIC
Ottawa-Urban Fringe	47	1977	1:25,000	4	9.00	CIC
Oxford[4]	28	1961	1:63,360	1	1.00	CIC
Parry Sound	31	1962	1:126,720	1		
Peel[4]	18	1953	1:63,360	1	1.00	CIC
Perth[4]	15	1952	1:63,360	1	1.00	CIC
Peterborough	45	1981	1:63,360	2	2.00	CIC
Prince Edward[4]	10	1948	1:63,360	1	1.00	CIC
Pukaskawa National Park	53	1985	1:100,000	1	1.00	CIC
Renfrew	37	1963	1:63,360	4	2.00	CIC
Russell-Prescott	33	1962	1:63,360	2	2.00	CIC
Simcoe[4]	29	1962	1:63,360	2	1.00/map	CIC
Soil Associations of Southern Ontario	30	1960	1:633,600	1	2.00	CIC
Stormont	20	1954	1:63,360	1	2.00	CIC
Sudbury(41I)[2]	49	1983	1:250,000 1:50,000	1 10	1.00 1.00/map	CIC CIC
Thunder Bay (52A)[2]	48	1981	1:250,000 1:50,000	1 8	1.00 1.00/map	CIC CIC
Timmins-Noranda-Rouyn (42A, 32D)[2]	46	1979 1979	1:250,000 1:50,000	1 6	1.00 1.00/map	CIC CIC
Victoria	25	1957	1:63,360	2	2.00	CIC
Waterloo	44	1971	1:25,000 1:100,000	45 1	4.00 included	CIC
Wellington	35	1962	1:63,360	2	2.00	CIC
Wentworth	32	1965	1:63,360	1	2.00	CIC
York[4]	19	1955	1:63,360	1	1.00	CIC

[1]Ontario Institute of Pedology; [2]No report prepared; [3]Consumer Information Centre; [4]Maps available, report out of print; [5]This map was originally printed at a scale of 1:95,040, but reprinted at a scale of 1:63,360; [6]Map and report out of print.

Ontario Institute of Pedology
Guelph Agricultural Centre
P.O. Box 1030
Guelph, Ontario
N1H 6N1
(519) 767-3572

Consumer Information Centre
Ontario Ministry of Agriculture and Food
801 Bay Street, Main Floor
Toronto, Ontario
M7A 2B2
(416) 965-1421

SOIL SURVEY IN ONTARIO - *THEN AND NOW*

T. P. Hagerty

Checking a peat soil in Prescott County. Circa 1930's.

Historical Perspective

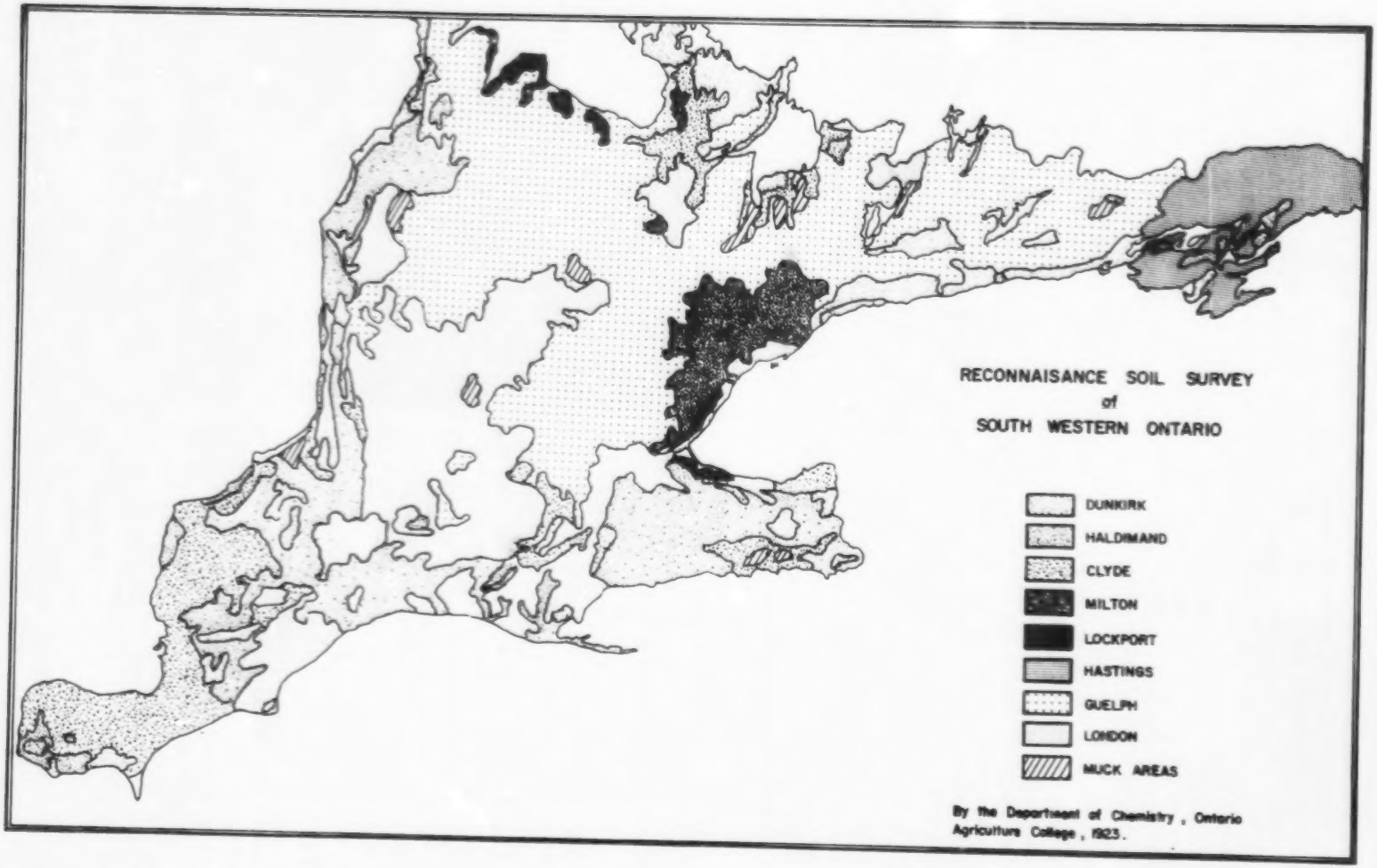
It was early in this century when the first attempt was made to inventory the nature and distribution of soils in Ontario. In fact, the first soil survey ever undertaken in Canada was begun in Ontario in 1914 by the Department of Chemistry, Ontario Agricultural College. This first report, published in 1923, covered all of Southwestern Ontario and identified only nine soil series. While this was unquestionably a crude picture, it represented a quantum leap forward in the understanding of our soil resource. The purpose of this initial survey was to identify and map the main soil types so that agricultural development and practices could be planned according to the nature of the soils. At the time however, other potential applications of soil survey information were also recognized. Today, soil survey information still fulfills this purpose but is also used for extension and educational purposes, land use planning and agricultural land preservation, soil conservation and identification of soil degradation prone areas, forestry, and a host of other applications.

The soil survey program in Ontario has been through several distinct phases as is reflected by changes in the agencies undertaking the survey projects, the scale of mapping, the information portrayed on the maps, and the survey methodology employed in collecting the information. The first period of the mapping program was undertaken by the Ontario Agricultural College (OAC) and produced a series of maps at a general scale of 1:126,720. These first efforts provided map coverage for the Counties of Norfolk, Elgin, Kent, and Middlesex. These maps were considered to be very detailed at the time they were produced but, in the face of the more intense demands being placed on soil survey information today, they have proven to be inadequate. As a result part of the current survey program involves re-mapping these areas.

Starting in the mid-1930's Ontario's soil survey program was organized on an informal cooperative basis among the Federal Department of Agriculture, the Provincial Department of Agriculture, and the Soil Department of the Ontario Agricultural College at Guelph. The College provided the headquarters and technical direction and the Federal and Provincial Departments of Agriculture provided staff and finances. During this same period soil survey programs were also being instituted in the other provinces.

During the time of this informal partnership a number of soil inventory maps and reports were produced. The first of these maps were still at a scale of 1:126,720 and the Counties of Haldimand, Welland, Carleton, and Durham were included in this coverage, as well as parts of Northwestern Ontario. Beginning in the late 1940's the scale of mapping was changed to a more detailed scale of 1:63,360. This change reflected the growing appreciation for the potential applications of soil survey information and the need for the most detail possible. In total, thirty six county reports were completed at this scale. A soil report to accompany the soil maps became available for the first time with maps published at the 1:63,360 scale. Additional information was also produced for some map sheets in Northern Ontario. Toward the end of this period a report was published at the detailed scale of 1:20,000 for the County of Waterloo. Once again this demonstrates the trend toward more detailed information.

In this overview, the formation of the Ontario Institute of Pedology (OIP) was a fairly recent event. Provincial support for soil survey had been ebbing toward the late 1960's and the early 1970's. It was in 1974, however, that the Provincial Government began to recognize alarming trends in the loss of prime agricultural land to competing land use and a provincial soil survey unit was established. Within a few years a formal agreement between Agriculture Canada, Ontario Ministry of Agriculture and Food, and the University of



The first soil survey done in Ontario in 1923 showed only nine major soil types for the entire province. A crude picture but an important first step.

Guelph had been negotiated and signed, bringing into existence the Institute in 1977.

The OIP agreement formalized the relationship of the three parties involved in soil inventory and for the first time clearly stated the goals and objectives of the program. These objectives fell into three main categories, inventory and interpretation, research, and extension. The agreement allowed the sharing of personnel and resources to achieve these objectives and is a good example of cooperation between the federal government, provincial government, and universities toward complementary objectives.

The Evolution Of Technology and Methodology In Soil Survey

Describing an Oshtemo Sand. Near Brighton, Ontario. May, 1937.

The manner in which soil survey has been undertaken has radically changed since the beginning of the program in Ontario. In early surveys the methodology entailed surveyors simply driving the concession roads checking periodically to see if the soil had changed. Soil inspections usually consisted of very shallow bore holes. Today extensive use of stereoscopic air photo interpretation allows the pedologist to delineate soil landscapes, assess drainage and pre-type soil components present before ever entering the field. Field checking is undertaken in order to verify predictions made on the basis of air photo interpretation. Specifications for the frequency of inspection, the minimum size of area which can be delineated at a given scale, and the overall final delineation density for the map are all followed as closely as possible. In the field a standardized data form ensures that the type and quality of information collected is consistent. The extensive data bases now collected are stored on computer and analyzed using up to date statistical methods. As a result the soils in modern surveys have been delineated more accurately and are better characterized.

The development and adoption of different survey methodology has taken place gradually and can be seen as an evolutionary process. Often some experimentation was required before it became clear how a new innovation might best be incorporated into the methodology. For example, in the case of air photographs, the initial use was simply as a mosaic base for field mapping. It was only after the photographs had been employed for some time that viewing paired photos stereoscopically was employed. Stereoscopic air photo interpretation gives a three dimensional view of the landscape and makes delineation of soil landscapes faster and more accurate. The development of the Munsell soil colour chart, a seemingly simple innovation, added greatly to the ability of pedologists to characterize and interpret soils in a consistent manner. The incorporation of the computer into the survey program also had wide ranging impacts on almost every aspect of data collection. Developments in laboratory techniques and instrumentation have also expedited the analysis of sampled soils and vastly enhanced the pedologist's ability to interpret the soil information.

As is the nature of technological advancement, the rapidity of its change has been increasing with time. Thus, since the formation of the OIP only ten years ago, the way in which soil survey is undertaken has changed almost as much as in the many years preceding. The most recent innovation has been the development and incorporation of the Geographic Information System (GIS). This is an electronic software package which allows the electronic storage and analysis of information in map form. The computer programs necessary for this are still undergoing rapid evolution of their own and the manner in which this innovation can best be made to serve a role in soil inventory is still being experimented with. To date the potential of this new tool has only begun to be explored in soil survey but it is already changing the way we think of resource inventory.

The potential of the GIS is so great that it can be expected to revolutionize both the way in which inventory is undertaken and the ability to interpret the information once the inventory is finished.

It would be incorrect to discuss the technological advancements made in soil survey without relating it to the progress made in the science of pedology as well. At the outset of soil survey in Ontario, soil science in Canada was in its fledgling state. The formation of the National Soil Survey Committee (NSSC) in 1945 was a major milestone for soil science in Canada. It was the aim of this committee to coordinate the national soil survey program. This involved recommending the loca-

tion of areas where soil survey work should be done, bringing about a greater uniformity in soil survey across Canada, addressing problems encountered in soil survey, and making innovations and advancements developed in one province available to all the units across Canada.

The NSSC was responsible for the development of the Canadian System of Soil Classification (CSSC). Every science requires a conceptual framework to allow the communication of ideas and theories. In pedology, the classification system provides this. The current system of classification adopted in 1978 replaced an earlier system, The System of Soil Classification For Canada, outlined in 1955. This system in turn replaced a system of field classification first developed in 1945. Each of these systems has improved upon its predecessor. The nomenclature has become more precise, the taxa better defined and the criteria for classification more based on soil properties.

The development of this system has been in response to a better understanding of soils in Canada and in turn the system has better enabled pedologists to identify areas of the science requiring investigation. In addition to changes in the classification system, the definitions of textural classes and slope classes have also been changed over the course of the soil survey program. The fact that soil textural classes and slope classes are defined differently on different maps depending on their vintage has been a source of confusion for the users of the information and has presented problems in applying interpretive systems in a consistent manner.

The number of applications to which soil survey information is being put has also greatly increased over the past few years. This means that the ability to interpret soil information for different purposes has also been evolving. The growing demands of interpretations on the information have also lead to changes in the maps themselves. For example, starting in the early 1960's it became recognized that some sort of topographic information was a critical input to many interpretations, and that the mapping of dominant slope class should be incorporated into the mapping methodology. Unfortunately, by this time, roughly sixty per cent of Ontario's area was covered with soil maps lacking topographic information.

A major jump in the importance of interpretive systems for soil survey information came in the early 1960's when a national system of land classification was conceived. The Canada Land Inventory System (CLI) was intended to classify Canada's land according to its suitability for a number of purposes, of which agriculture was only one. The system identified seven classes of agricultural capability and designated the type of limitations present with a subclass. Unfortunately, much of the soil map base for Ontario lacked topographic information necessary for the interpretations. In addition, much of the information characterizing the properties of mapped soils was qualitative in nature and did not lend itself to the application of a universal system of classification. As a result, the interpretive methodology employed was very generalized.

The interpretive maps were originally to be published at a scale of 1:250,000, but in the end the 1:50,000 scale working maps on which the original compilation work was done were also made available to the public. This represents a problem since the relatively detailed publication scale of these maps belied the fact that they were based on soil information at a much more generalized scale, and portraying much less specific information. In fact, the published 1:50,000 CLI maps were actually at a larger, more detailed scale than any of the soil maps from which they were produced, and portrayed information on subclass limitations for which the soil maps lacked sufficient information.

More recent soil surveys have incorporated CLI interpretations into their reports and for these areas the interpretive information is of a much higher quality. However, for other areas the original CLI maps still represent the best picture of agricultural capability.

The net result of all this evolution in technology, the science of pedology, and in the interpretive demands, has been to produce a set of map coverage for Ontario which varies widely in scale, quality, and information portrayed.

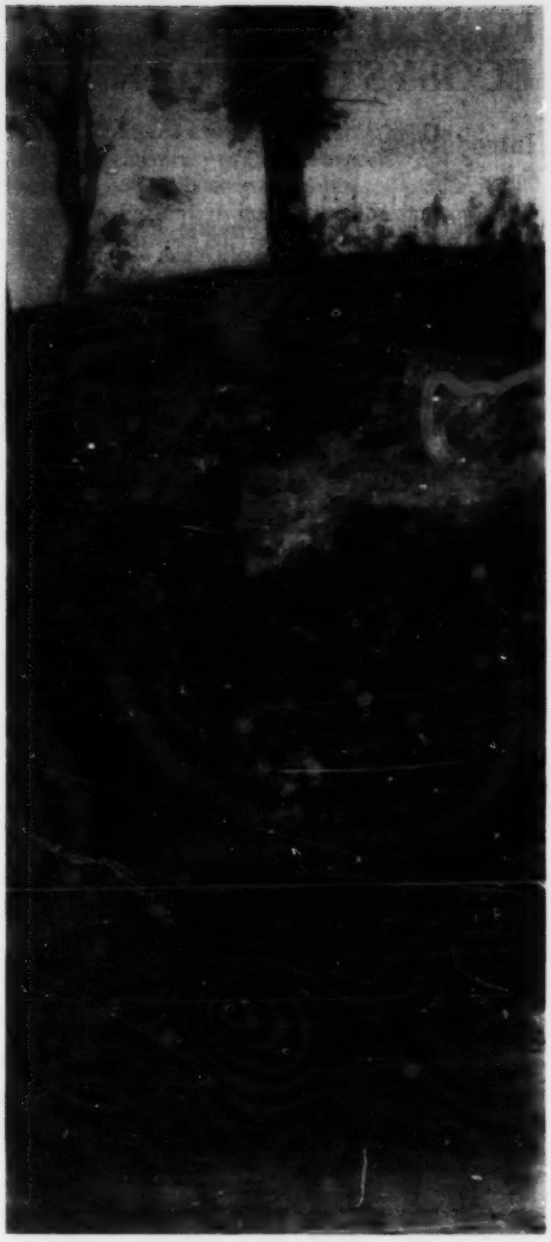
Peterboro County. Circa 1930's.

On the current schedule the Institute hopes to finish remapping the last of the old 1:126,720 scale maps in the not so distant future. Beyond the surveys now being undertaken this leaves only two full resurveys to be done in Kent and Durham Counties. However, this does not mean that the job of the soil survey will be completed. Although there will be a map data base in place for most of the important agricultural areas in Ontario this base will be inconsistent and difficult to interpret. The emphasis of the Institute will change at this time. Inventory activities may focus on short turn-around time upgrade projects to bring the data base to a consistent level of quality. Greater effort may also be focused on fulfilling the interpretation and extension objectives of the institute.

Upgrading the map base would involve two separate tasks which are complementary in nature. The first task would be to bring topographic component critical to interpretation into areas surveyed without topographic information. The potential application of digital terrain models in adding this topographic component to existing soil maps is something which the Institute may be examining in the future. The second task would be to sample the soils in the areas being upgraded in order to build a data base on the properties of soils which were mapped before sampling and lab analysis were standard practices.

As the situation now stands, the soil map data base for Ontario is being underutilized due to several factors. One is the lack of uniformity in the data base itself as discussed above. Another is the lack of resources within the Institute to develop interpretive packages and provide proper extension to users of soil information. With the quicker turn-around time on survey upgrade projects, conceivably, more resources could be available within the Institute to develop applications for the information, and interpretive packages for agricultural extension personnel.

With one decade behind the OIP we are now looking to a future which will see less emphasis on routine survey and more on the areas of technology transfer, extension, interpretation, and application development.



Inspecting stratified sands and silts in Peel County. July, 1934.

FOREST SOIL AND ECOSYSTEM WORK

Introduction

R.K. Jones

The Ontario Institute of Pedology has been actively involved in forest land classification, mapping, and interpretation programs in both southern and northern Ontario since about 1978. We wish to acknowledge that much of this work has been accomplished as a result of close associations developed between the OIP, the Ontario Ministry of Natural Resources (OMNR), the Canadian Forestry Service, the Faculty of Forestry, University of Toronto, and the School of Forestry, Lakehead University.

The Northern programs have included the undertaking of, and participation in, various Forest Ecosystem Classification (FEC) studies and in Prime Site/Prime Land Inventory programs. These programs are designed to provide forestry staff within the OMNR and industry with improved land and soil related information for the purpose of planning and conducting forest management activities. The southern programs are, and have been, conducted under contract with OMNR. The first contract (1980-1984) concentrated on the development of productivity ratings for most of the major commercial species using existing soil survey information and, on an "on-site" basis, using primary soil description data in Central and Southwestern Regions. The current Soil Interpretation and Training Program for the Algonquin Region (1985-1989) is essentially a continuation of the earlier contract work, but with a more comprehensive data collection effort.

Reforestation. Kemptville School Farm, Grenville County. Circa 1930's.

Forest Ecosystem Classification Programs, Northern Ontario

R.K. Jones

Beginning in 1979, the OIP became involved in the development of methods for classifying, mapping and interpreting forest ecosystems in the boreal forest region. The first program was begun in the Clay Belt region of northeastern Ontario and was a cooperative study with the OMNR, the Canadian Forestry Service, and Environment Canada. This work involved the collection and classification of soil, vegetation, and stand information for the mature forests of the region for the purposes of developing harvesting and regeneration interpretations. A wide range of computer-assisted, multivariate analytical procedures were tested and used to classify, ordinate, and integrate the site, soil and vegetation data. Mapping procedures also were developed using standard 1:15,840 black and white stereo air photos. Results from this work were published (1983) in a water proof field guide format entitled "Field Guide to Forest Ecosystem Classification for the Clay Belt, Site Region 3e" (by R.K. Jones, G. Pierpoint, G.M. Wickware, J.K. Jeglum, R.W. Arnup and J.M. Bowles).

Following the developmental work in the Clay Belt, similar forest ecosystem classification (FEC) programs have been initiated in Ontario's central and western boreal forest regions (North Central and Northwestern Regions, OMNR). These programs are attempting to incorporate the evaluation of forest productivity information more directly into the development of the ecosystem classes. The North Central Region FEC program is being undertaken cooperatively by the Ministry of Natural Resources out of Thunder Bay (William Towill) and the Canadian Forestry Service out of Sault Ste. Marie (Richard Sims). The Northwestern Region FEC is being conducted primarily by the Ministry of Natural Resources out of head office (Peter Uhlig) and in the Northwestern Region (Bob White). The OIP is involved in these programs, particularly the Northwestern Region program, in more of a consultative role in contrast to the earlier Clay Belt work. A first approximation of a forest ecosystem classification has been prepared for the North Central Region. The Northwestern Region hopes to have its classification outlined over the next year.

Prime Land Inventory

R.K. Jones

The Prime Land Inventory program of the Ontario Ministry of Natural Resources is the initial stage of a broader initiative called Prime Site Management. The Prime Land Inventory comprises an interpretive survey of the available forest land base in terms of its inherent capacity to support forest production. "Prime Land" is considered to be land upon which the growth rate of commercial tree species is better than that of other sites, due to differences in the inherent capability of the soil to supply moisture and nutrients for forest growth. Prime Site Management refers to the directing of the forest land management decisions in accordance with the highest overall return on investment. Many factors are considered when making these decisions including such things as stand growth, current stand conditions, wood supply requirements, current silvicultural knowledge, constraints, financial resources available, social and economic conditions, and proximity to mills.

Prime Site, and hence Prime Land Inventory programs are being pursued and are at various stages of development in Northeastern, Northern, North Central, and Northwestern Regions of the Ministry of Natural Resources. The OIP has been involved in the development of the "Prime Land" phase in all of these programs, except for Northeastern Region. The Institute's contribution to this work has been primarily that of providing advice on:

- the development of soil and land criteria for defining primeland interpretive classes

- the preparation and interpretation of existing OIP and other land resource inventory maps/legends, digitization of soil/land resource maps and

- the structuring of soil name and polygon attribute computer files and reports

- the design of the components required for input to a geographic information system,

- the testing of the reliability of existing land resource inventories

- the design and auditing of semi-detailed forest soil inventories for selected priority management areas

- assisting with the transfer of this information and its use to Ministry field staff

Approaches To The Evaluation Of Forest Soil Productivity In Ontario -- Workshop

R.K. Jones

The OIP hosted a two day workshop held in the spring at the University of Guelph to review approaches to, and applications of, forest soil productivity information. Participants included representatives from Ontario and Canadian governments, industry and universities in Canada and the United States. The presentations and discussions concentrated on two areas of concern: methods for estimating the productive potential of the land base, and procedures for applying productivity information in forest management, planning, and policy development.

The workshop proceedings are now available from the OIP at a cost of $5 payable to the University of Guelph. They may be obtained by writing to the address below:

Publications
Ontario Institute of Pedology
P.O. Box 1030
Guelph, Ontario
N1H 6N1

Soil Interpretation And Training Program For Algonquin, Central and Southwestern Regions, 1985-89.

R. Baldwin, E.P. Taylor, R.K. Jones, and A.M. Gordon

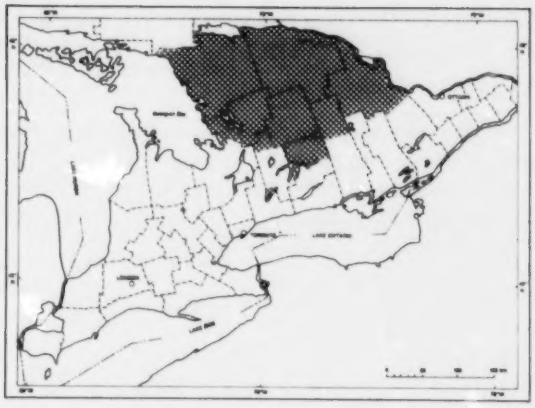
The Ontario Ministry of Natural Resources and The Canadian Forestry Service, awarded the Ontario Institute of Pedology (Land Resource Science) a four year contract in 1985 to do forest site classification and interpretation work in Southern Ontario. This program is both a continuation of the previous work in agricultural Southern Ontario and an initiation of new work in the Algonquin Region (see map).

The goals of the program are as follows:

1) to classify those forest ecosystems which are considered critical to forest management practice;

2) to interpret the ecosystems for forest growth and the potential for competitive vegetation and;

3) to help forestry staff learn how to identify important soil/site properties for the purpose of applying the interpretive information.



Algonquin Region. O.M.N.R.

An account of the past year's activities follows:

1. Stem Analysis - White Pine and Norway Spruce

During the fall of 1985 and the winter of 1986, fifty four plots of Norway Spruce and forty one plots of White Pine were established for the purpose of a detailed soil site study. This work is to be completed in two stages. The first stage is to do mensuration (growth and yield) work using stem analysis procedures. The second stage is to complete detailed descriptions of soil physical and chemical properties in each plot. This data will then be analyzed using multivariate procedures for the purpose of obtaining regression equations to predict soil-tree growth relations. To date, stage one has been successfully completed. The results of this work with Norway Spruce have been summarized in a research paper format and accepted for publication. A similar paper is in progress regarding the research work with White Pine.

2. Field Research - Algonquin Region

Sixty two study plots were established in the Algonquin Region during the 1987 field season. Soil, forest stand, vegetation, and yield information were gathered in each case. To date, one hundred fifteen standard sample plots have been sampled. In addition to the study plots, nine temporary observation stations (for a total of forty) were set in place for the purpose of evaluating the potential for competitive vegetation. Most of the field research was in the eastern half of the Algonquin Region (i.e. Upper Ottawa Valley).

3. Technology Transfer and Training

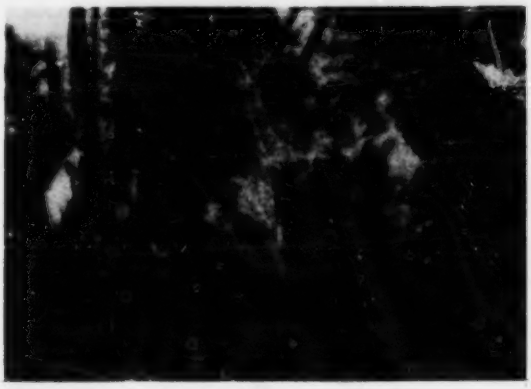
Two soil and silviculture courses were offered in 1987: A soil and pine silviculture workshop at the Petawawa National Forestry Institute for Algonquin Region Staff, and a joint site and silvicultural workshop for Central and Southwestern Region OMNR staff. Technology Transfer activities in 1987 involved one-day soil courses, on-site consultations, speaking engagements, and tours.

4. Data Analysis

Data collected during the 1987 season has been entered into computer files for subsequent analysis. Tree growth information will be generated using stem analysis techniques on the Tree Ring Increment Measure (TRIM) system. Soil physical and chemical laboratory analyses have been completed by the OIP characterization laboratory and Dr. Andrew Gordon's forest soil laboratory, respectively. Data analysis is planned to address both soil-vegetation and soil-tree growth relationships.

5. Plans for 1988

Field research is planned for the northern portions of the Parry Sound District. At least two regional soil (or soil and silviculture) workshops are scheduled. Informal technology transfer activities will be minimized so that the objectives related to research and development will be attained.



Examining tree roots. Waterloo County. Circa 1930's.

RESEARCH

Introduction

B.D. Kay

The research program in OIP supports the ongoing inventory and interpretation program. The long term objective of this research is to increase the effectiveness of soil survey and the reliability of interpretations which can be placed on the inventory information. Research which meets this objective is carried out in several areas. Studies on the genesis of soils are leading to a better understanding of the process of soil formation and the variability in soil development within the landscape. These studies aid in understanding the basis for differences between soils with the subsequent impact on mapping programs in the field. Studies are also directed to methods for speeding up the ongoing survey program. Data collected as part of the inventory program must be interpreted for a number of purposes. Research is directed to enhancing our capability in predicting the response of soils to factors such as erosion, compaction, and structural deterioration due to loss of organic matter based on inventory data. Studies are also underway to more effectively evaluate the suitability of soils/climate for different crops. Inventory information is also used as part of the land use planning process, and research is directed to enhancing the utility of inventory information in land use planning and developing a streamlined procedure for land evaluation.

Research is carried out by personnel associated with Agriculture Canada and the University of Guelph.

Funding for this research is obtained by scientists from operating funds of their respective agencies. Operating funds available to faculty at the University of Guelph are derived from the OMAF research contract with the University. Additional funding was obtained in 1987 from the following agencies:

- Environment Canada
- Natural Sciences and Engineering Research Council - Ontario Ministry of Natural Resources

Support provided by these agencies complement the projects carried out with operating funds and significantly enhance the effectiveness of our research program.

A highlight of the research program in 1987 was the review of the programs supported by OMAF. The review was carried out by the Agricultural Research Institute of Ontario (ARIO) and provided the basis for a discussion of research proposed to be carried out during the next four years. ARIO supported research which would be directed to the following objectives:

- to develop methodologies for agricultural land rating and evaluation applicable to local planning needs in Ontario

- to develop methodologies to characterize the extent and impact of land degradation in Ontario

-to develop a greater understanding of soil distribution and variation for improved definition of map unit composition and increasing the quality of soil data being used in a county level geographic information system

-to provide inventories and methodologies that can be used to assess the impact of land use policies, programs and/or proposals on agricultural lands or activities

The research reports which follow provide a "flavour" of the research carried out in OIP. Further details on specific projects can be obtained by contacting the principal investigator directly or through the Co-ordinating Director of the Institute of Pedology.

Potential For Soils To Transfer Pesticides To Water Systems In Southern Ontario

I.J. Shelton, G.J. Wall and W.T. Dickinson

The purpose of this study was to determine where, in the Southern Ontario Great Lakes Basin, high amounts of pesticides were being used on soils which can readily transport pollutants to water systems. The potential for soils to transport pesticides was assessed for 263 townships. Six potential problem categories were developed, each of which described a different combination of pesticide use (High, Moderate or Low) and soil potential for pollutant transfer to surface or ground water systems.

Generally, the areas where pesticide transfer to surface water is most likely are located in Southwestern Ontario (Townships in Lambton, Kent, Elgin, Oxford, Brant, Haldimand-Norfolk and Niagara Counties). Potential problems with ground water pollution are also concentrated in the same area, although ground water pesticide contamination was not predicted to be as widespread as that of surface water. Townships which were ranked highly for both surface and ground water potential problems were Dover, Raleigh and Tilbury East (Kent County); Dawn, Enniskillen, Moore,

Plympton and Sombra (Lambton County) and Niagara-on-the-Lake (Regional Municipality of Niagara). Townships that might be expected to have fewer problems with pesticide pollution were those in South-central and Eastern Ontario. It is hoped that the information from this study can be used in general, regional level exercises to identify, priorize and target "Potential Problem" areas for further investigations.

Nonpoint Source Pollution Problems in Intensive Agricultural Areas of Southern Ontario

E.A. Pringle, G.J. Wall and W.T. Dickinson

Inventories of farm management practices and stream water and sediment quality in the intensive agricultural areas of Southern Ontario were examined to assess the area's potential for agricultural nonpoint sources of pollution. This study was carried out as part of an international project aimed at establishing the current state of water quality in the St. Clair River, Lake St. Clair and Detroit River. The analysis revealed high fertilizer and pesticide use (429 and 2.4 kg/ha) respectively. Phosphorus application occurred at three times the recommended rate in some areas. Soil and water conservation practices which could reduce erosion and subsequent water quality impairment were used minimally. Tributary water quality data indicated the presence of all eight contaminants (polychlorinated biphenyls, hexachlorobenzene, octachlorostyrene, phosphorus, cadmium, chloride, lead and nitrogen) analyzed. Phosphorus and cadmium consistently exceeded water quality standards in all tributaries. Agricultural pesticides such as atrazine and alachlor were found in 93% and 15% of all Thames River samples respectively. As a result of limited data, several computational methods were used to calculate loading rates. Best estimate annual loads for phosphorus, cadmium, chloride, nitrogen and lead were 3.18, 0.002, 285, 35 and 0.057 kg/ha respectively. High tributary contaminant concentrations and resulting loads suggested that agricultural nonpoint source pollution is contributing to impaired water quality in the study area.

Recommendations were made to improve water quality monitoring and create better water quality standards to facilitate improved assessment and tracking of water quality problems. In efforts to reduce agriculture's contribution to water quality degradation, recommendations were also made to promote comprehensive land management at the farm level.

The Effect Of Variable Percentages Of Corn Residue On Soil And Water Loss

E.A. Pringle, G.J. Wall and B.K. Hohner

Comparing soil and water loss between conventional and conservation tillage.

The Guelph Rainfall Simulator II was used to develop a method to evaluate the effects of varying amounts of corn residue on reducing soil and water losses on a silt loam soil at the Elora Research Station. Hydrological properties such as runoff volume and infiltration, along with physical characteristics such as total soil loss and bulk density were compared on four different primary tillage treatments (moldboard plow, offset disc, chisel plow and no till) and associated corn residue cover (5, 14, 30 and 80% respectively). In addition, the effects of varying corn residue cover on soil and water losses for a single tillage treatment (chisel plow with residue ranging from 15-45%) were compared. Fifteen minute simulator runs with a rainfall intensity of 2.67 mm/min were performed on the 1 m^2 plots in June 1987 (corn at four leaf stage, replicated three times) and in November 1987 (after fall tillage, replicated twice). Another set of runs is planned in the Spring of 1988 to complete the data set. The average soil loss from the moldboard, disc, chisel and no till plots in June were 44.7, 30.4, 25.6 and 8.3 g/m^2 respectively. The losses from the June runs on the chisel plow plots with 15, 30 and 45% residue cover were 35.5, 25.8 and 26.0 g/m^2 respectively. This may indicate that soil loss does increase with a decrease in surface residue cover. Runoff in June was much lower on the no till plots (0.7 l/m^2) but little difference was observed between runoff volumes on the chisel, disc and moldboard plots (3.4, 3.5 and 4.3 l/m^2 respectively). Much less runoff and sediment loss occurred in November (.7 l/m^2 and 21 g/m^2) for all treatments which was most likely due to the great surface storage created by fall tillage. The Spring 1988 runs should indicate

ether frost action over winter creates changes with
ferent tillage with respect to storage and infiltration
pacity of this soil. The complete data set will provide
easonal picture of how different tillage treatments
l residue covers effect soil and water losses. Recom-
ndations can then be made to farmers regarding op-
um soil management which will keep soil, nutrients
l pesticides on the fields and out of streams and
ers.

ne Rainfall Simulator II.

ne Effectiveness Of Interseeded Red over In Silage Corn To Control Soil rosion

A. Pringle, G.J. Wall and B.K. Hohner

The Guelph Rainfall Simulator II was used in
vember of 1987 at the Elora Research Station to
mpare soil and water losses from plots of harvested
age corn with and without interseeded red clover.
infall was applied for ten minutes on a $1m^2$ plot at an
ensity of 2.67 mm/minute in November, 1987. This
rm was replicated three times per treatment. Particle
e, surface roughness and residue cover, antecedent
isture content and slope were determined for each
t. Time to ponding and runoff were measured
ring the run. Total runoff and soil loss were also
corded. Calgon dispersed particle size analysis indicated that the soils ranged from a clay loam to a silty clay loam. Surface cover averaged % on the corn plots and % on the corn/clover plots. The average slope for all plots was 3.0%. Runoff and sediment volumes for the corn plots averaged 11.9 l/m^2 and 125.3 g/m^2 respectively and 7.1 l/m^2 and 56.3 g/m^2 respectively for the corn/clover plots. T-test results showed that the means for runoff and soil loss were not significantly different. These preliminary results suggest that red clover does not become sufficiently well established in autumn when interseeded into silage corn to provide significant erosion control over winter.

Seasonal Variation In Selected Soil Physical, Chemical and Hydrological Properties

G.J. Wall, I.J. Shelton, B.K. Hohner and E.A. Pringle

Recent investigations into common soil physical (density, structure, strength) and related hydrological properties have reported wide seasonal variations in their respective values. These observations have been particularly evident in temperate climates where freeze-thaw events are common. This study was initiated to establish the magnitude of seasonal variability in selected soil physical, chemical and hydrological properties in Southwestern Ontario.

Three soils (Guelph loam, Fox sandy loam and Haldimand clay) with a history of corn crop production and relatively uniform slopes (4-5%) were chosen for study. Seasonal measurements of the soil physical (crust strength, soil erodibility, bulk density, aggregate stability, particle size), chemical (moisture, bioactivity, pH), and hydrological properties (runoff, infiltration, soil loss, time to ponding and runoff) were made. Hydrological measurements were made on 1 m^2 plots following high (2.67 mm/min) and low (0.69 mm/min) intensity simulated rainfall events. Measurements were made in June, August and November of 1987 with further observations planned for March, 1988.

Soil properties that tended to increase in value from June to November included runoff, soil loss and antecedent moisture. Properties that tended to reduce over the period of study included bioactivity, infiltration, and time to ponding and runoff. Soil crust strength tended to be greatest in August while similar in June and November. Sediment concentration was similar for all soils and throughout the seasons. Analyses of trends in bulk density and particle/aggregate size distribution and stability are ongoing.

Study results will aid in the testing and calibration of event based soil and hydrological models.

Soil Aggregate Stability To Rainfall Energy

G. J. Wall, B. Grant, and E. A. Pringle

The water stability of soil aggregates has proved to be a useful parameter in studies of soil structure and stability. Methodologies to quantify the stability of soil aggregates have often employed a variety of wet sieving techniques. This study was conducted to develop a method to assess the stability of soil aggregates to rainfall energy for use in research into rainfall induced soil detachment and transport processes.

Three soils (sandy loam, clay loam, and loam) under contrasting cropping practices (continuous corn, tobacco, and forage) were used. The initial aggregate size distribution of the soil was determined in duplicate, by sieving into seven fractions (4mm, 2.8-4mm, 2-2.8mm, 1.0-2mm, 0.5-1.0mm, 0.25- 0.5mm, and .25mm) in a rototap machine for two minutes. To test the stability of the aggregates the soils were also subjected to slow wetting by capillary action (twenty minutes) and a simulated rainfall event (twenty minutes at an intensity of 101.9 mm/hr and a pressure of 7psi). After each event the aggregate distribution was determined by air drying the sample and sieving it in the same manner used to determine the initial aggregate distribution.

The dry aggregate size distribution showed differences between soil types and cropping histories. Little significant change in size distribution occurred when soils were wetted by capillary action, but soils subjected to wetting by rainfall energy showed a significant change. The effect of rainfall energy on aggregate stability was most apparent in the smaller fraction (.25mm) of the soil for all textures. In all cases the rainfall energy increased the number of fine aggregates. Preliminary data shows that by comparing the aggregate distribution before and after the rainfall event the small aggregates under forage crops are more stable than the small aggregates under row cropping within each texture. The mean diameter (D-50) of the loam soil under forage production decreased by twenty percent while the continuous corn showed a forty nine percent decrease. The clay loam had similar results with the continuous corn showing a sixty percent decrease and the forage showing a fifty five percent decrease in the D-50. The sandy loam soils had smaller percent changes for D values due to the initial small size of the aggregates. The test results indicate that this proposed methodology has potential for assessing the stability of soil aggregates to natural rainfall energy.

Characterizing The Response Of Soils To Cropping Systems

B.D. Kay

Information on rates of change of the structure of different soils under different cropping systems is vital to research in soil conservation. A conceptual model has been developed which facilitates quantification of cropping history in relation to rates of change of soil structure. The model relates structural form (eg. total porosity, poresize distribution, aggregate size distribution), structural stability (eg. wet aggregate stability, dispersible clay, friability), stabilizing materials, biological factors, and forces which may be exerted on the soil. Soil and crop management practices influence the nature and magnitude of forces involved, biological factors, and the level of stabilizing materials. The model has been applied, for illustrative purposes, to five different cropping sequences involving the production of corn (conventional tillage) and bromegrass grown for different lengths of time over a fifteen year period.

The following types of applications of the model are conceived:

- a quantitative framework for assessing the extent and nature of impact of new soil and crop management practices on the rates of change of soil structure

- use of relative values of structural form, structural stability, level of aggregating constituents, and biological activity to assess the "quality" of a soil at any point in time

- a framework for characterizing the susceptibility of soil to structural changes due to cropping systems.

Assessment, refinement, validation and application of the model will require extensive research carried out on soils of different type and degree of degradation and under different climatic conditions, crops and soil management practices. It is hoped that in the long term the model will permit prediction of the rates of change of soil structure under different cropping systems using standard inventory information in the same manner that rates of erosion can be predicted now using the universal soil loss equation.

Remote Sensing - Land Resource Information Systems

R. Protz, A. Nurwadjedi, and B. Proud

As satellite systems incorporate higher resolution sensors, i.e. T.M. (28 m pixels), SPOT (10 m and 20 m pixels), we are able to differentiate ever greater detail on the earth's surface. Satellite data is collected in analog form and computer systems are in place to convert all spectral data into digital form. This digital data can easily be used in small area segments on micro computers. It is clear that an efficient system of monitoring changes over small land areas is now possible. We have chosen the township, a basic political unit, as our land area. Proposed land use changes are first made at the township level.

One of the questions asked by users of satellite data is - how much information am I losing by using a 28 or 20 or 10 metre pixel?

To provide a meaningful answer we decided to work with airborne MEIS-II data. The Canada Centre for Remote Sensing collected MEIS-II imagery (3.1 m pixels) of Dereham and Norwich townships in Oxford County in May of 1985. This airborne imagery has been corrected for all aircraft, geometric and radiometric errors.

This MEIS-II data set is being used to correlate soil organic matter content with radiance values of the T.M. wavelengths. The results may lead to the development of a system of mapping soil organic matter content from satellite data. In an ancillary study we will compare colour Infrared photographic data with MEIS-II for mapping soil organic matter in digital and pictorial mode.

Norwich township has also been designated as Ontario's intensive Agriculture test site for Airborne C-band radar and future satellites.

As the data collection continues we will be working in co-operation with OMAF, the Canada Centre for Remote Sensing, the Ontario Centre for Remote Sensing, PCI Ltd., and Marshall Macklin Monoghan to incorporate all the satellite and airborne data into a user friendly Image Analysis System associated with the Oxford County Geographic Information System.

Development of an Index of Soil Quality

R. Protz, D. McCabe, and E. Dickson

Several researchers are now measuring short-term (one to three years) soil improvement. The agricultural sector is and will continue to face questions from an environmentally conscious society about the extent of soil degradation. The question always present but not yet answered is - soil degradation from what state of soil quality? In this project we are attempting to define the state of soil quality on never cultivated sites. At this point in time we are working on four sites within the Lake Erie Basin. We have sites on the Fox, Donnybrook and Smithville soil series. As most of the degradation under cultivation occurs within the A horizon we have sampled seven soil profiles in 1 cm thick layers to a depth of 16 cm. To measure the contribution of faunal activity to soil quality we have used the distribution of Cesium 137 with depth as a measure of the rate of organic matter incorporation. This is based on the assumption that the radioactive isotope Cesium 137 was deposited in relatively consistent concentrations on all soil surfaces during the high altitude nuclear tests of the 1950's, effectively flagging the state of the soils at the time.

Compressibility measurements are being used as an indication of soil strength variation with depth. Soil micromorphological samples are being used to measure natural void and aggregate distribution.

These data will be used to develop an "Index of Soil Quality" to which properties of cultivated Ap horizons can be compared. Our initial perception is that coarse textured soils may have increased whereas fine texture soils may have decreased in "quality" with present management practices.

Oxford County. Circa 1930's.

Development Of A Rating System For Soil Compaction Susceptibility

R.A. McBride

Soil compaction research, originating largely in the U.S., has served to advance soil mechanical theory and has empirically examined the influence of traffic and tillage-induced compaction on crop growth and productivity under a limited range of soil conditions. I have made few inroads, however, into the estimation of soil structural or porosity change with variable wheel loadings, or the ranking of a wide range of soil types by their inherent susceptibility to compression. The research project described here has these latter two aspects of soil compactibility as its objectives.

The shortfall in our understanding of these aspects of compaction greatly limits our ability to rationally plan the use of our agricultural land resources, or the sustainability of production. Furthermore, it hinders the development of mitigative and corrective technologies or the application of preventive measures.

Compression testing of forty four soil horizons sampled from the Regional Municipality of Niagara has shown that, in accordance with soil mechanics theory, a linear "virgin compression line" (VCL) can be plotted where e = f (log 10). Both the upper (UPL) and lower (LPL) plastic limits of a soil can be plotted on its VCL but these indices have been shown not to occur at a unique or characteristic stress for all soils. The plastic soils used in this investigation equilibrated at their respective LPL's when subjected to stresses ranging as widely as 0.26 to 1.84 MPa. Similarly, the stress at the UPL ranged from 3.9 to 268 kPa, a barely mutually exclusive range relative to that of the LPL.

These normal stresses, however, were found to be correlated with the clay and organic matter contents of the soil. The predictive capability of this compression-based test for the Atterberg limits was better for the LPL ($r^2 = 0.93$) than for the UPL ($r^2 = 0.79$).

There are several areas for which these research findings have important implications. Firstly, the relationships revealed by this compression-based test procedure suggest that the LPL and UPL can be used as reference points to help define the density-moisture-stress function in compaction modeling of Ontario soils. Immediate use could thus be made of the existing and substantial soil consistency limit data in mechanical testing. Much of this data is readily retrievable from computerized soil information systems in Ontario and elsewhere.

Secondly, the possibility exists to unify what has for decades been a cumbersome, two-stage lab procedure for soil consistency limit determination. Any test procedure for soil consistency limit which provides meaningful indices but which reduces or eliminates the inappropriately high level of subjectivity should be considered to supersede the current ASTM methods. At the very least, this new procedure defines the boundary between plastic and non-plastic soils more definitively than the current deunified test.

Thirdly, it should be possible to better define the role of organic matter in the compaction process (e.g. content, type, degree of humification) with respect to its influence on the energy status of soil, water and on soil strength parameters.

And finally, by linking soil compactibility and consistency, it may be possible to further refine the identification of optimum field conditions for tillage operations which will minimize subsoil compaction and maximize the efficiency of topsoil tillage.

Water Table - Rainfall and Soil Temperature Observation

B. K. Hohner

Since 1978, water table, rainfall and soil temperature data have been collected for selected soils as part of the soil inventory program. Seventeen water table-rainfall sites and four soil temperature sites are being monitored in the Regional Municipality of Niagara and twenty one water table-rainfall sites are monitored in the Regional Municipality of Haldimand-Norfolk.

In 1984, a summary of the first five years of data collection, entitled the "Seasonal Fluctuations of Apparent Water Tables in the Regional Municipalities of Niagara and Haldimand-Norfolk 1978-1984", was published (OIP Publication No. 85-6). Periodically, this publication will be updated to incorporate new data as it continues to be collected.

It is intended that this information would by useful to persons involved in agricultural, engineering, and environmental quality studies, along with the survey of Ontario's soils.

Characterizing Physical Properties Of Potato Producing Soils

B. van den Broek, W.Stevens and D.M.Brown

Currently, the University of Guelph in cooperation with the Ontario Ministry of Agriculture and Food is conducting a research study with the objective of developing a computer program which will permit a better scheduling of irrigation applications in potato crops. As part of the input requirements for the computer program, there was the need for a better characterization of the soils in the Alliston area on which the field experiments were being conducted.

A detailed survey on three farms in the Alliston area was conducted to characterize the physical features and to determine the variability of the soils (within plots on the same farm and between the farms). A total of forty soil profiles were examined, described and sampled on the three farms. Preliminary results of the findings were released for the research study. A similar study will be conducted on the Cambridge Horticultural Research station in the coming year.

Potato crop on Kemptville School Farm, Grenville County. Circa 1930's.

EXTENSION, TECHNOLOGY TRANSFER AND TECHNICAL ADVISORY SERVICES

T. P. Hagerty

Introduction

The term extension refers to any program which geographically extends the educational resources of an institution to persons otherwise unable to take advantage of such resources. In the context of the Ontario Institute of Pedology (OIP), extension efforts are directed towards helping users apply soil information to their own situation. The OIP's primary concern is that Ontario's agricultural soil resource base be properly managed so that it may continue to meet Ontario's needs in the future. It is the mandate of the Institute to inventory the nature and extent of the agricultural resource base in Ontario and to produce interpretive information which will help ensure this proper management. Management of the soil resource takes place at two very contrasting planning scales, regional and on-site level.

For the Institute, this implies two disparate audiences or user groups with very different extension needs. The planning community in Ontario uses soil information in support of OMAF's Foodland Guidelines as one component in the planning process. These resource based users of soil information require an understanding of how to use the maps and reports, the principals and methodologies involved in producing soil resource inventories, the strengths and limitations of the information, and the suitability of using the information for different purposes. Extension activities, workshops and seminars are held for members of the planning community both as a regular part of the county survey projects and in response to special requests.

The farmer, as a soil manager, is supported by a fairly extensive network of agricultural extension personnel. These are in the form of OMAF's agricultural representatives, soil and crop specialists, and soil conservation advisors. Since the farm community is a very dispersed population the extension specialists are necessarily also dispersed. The Institute's role in the on-farm delivery of information is more oriented toward support of the agricultural extension personnel. In this context perhaps the term "technology transfer" better describes the role the Institute can play in that it involves more the development of interpretive management packages and resource material for extension staff than direct extension itself. To date the Institute has not had sufficient resources to adequately address the technology transfer needs of this user group.

In the past, this extension support role has focused on training extension personnel in the on-site identification of soil properties and the evaluation of soils for different purposes. The OIP publication "Field Manual For Describing Soils" has become the accepted guide in Ontario for describing and assessing soil properties.

It is envisioned, however, that in the future, the Institute's role in extension support may expand. Within the coming years the Institute may becomes less involved in full-scale survey projects and more geared toward short term upgrades of existing surveys. This change in direction for the Institute could have two different effects on extension activities being carried out. First, since this type of upgrade project might be less demanding in terms of professional time this would allow personnel at the Institute to spend more time working on soil management related interpretive packages for use by agricultural extension personnel. Second, the better characterization of landscapes and soil properties in the various counties being upgraded would make the soil information more relevant to the on-site applications of this same group.

Members of the Institute are looking forward to increased interaction with the agricultural extension personnel. There is no question that greater access to the abundant experience available through the field staff would be of great value when interpreting soil information. Better soil information, on the other hand, put in a context relevant to the situations being addressed by field staff, would provide a valuable framework on which field staff can communicate and organize their experience and observations.

Demonstration of the Rainfall Simulator II. 1987.

Extension and Technology Transfer Activities in 1987

Extension Coordinator - 6 Month Contract

For a six month period in 1987 the OIP hired an extension coordinator to work on two priority items identified by the extension committee of the Institute. The first of these was the development of an OIP user contact/mailing list. This list contains the names and addresses of the majority of the OIP's many diverse users. The list is computer based and classifies users by two areas of interest. This allows the Institute to undertake complete mailings to all the listed users, or selective mailings to smaller subgroups of the main list based on their areas of interest. In addition, this list now gives the Institute a firm concept of the specific users of our information and the relative size of these user groups. Developing a good system of contact with our user groups is an essential prerequisite for identifying and fulfilling their extension needs.

The second initiative was the preparation of background information for a new OIP extension publication. A tentative title for this publication is "A Guide to the Use of Soil Information in Ontario". It will include both generic information on the use of soil maps and also specific information on the various levels of soil information available across the province. Both of these initiatives were undertaken to fulfill extension needs that were identified in the OIP user survey which was published in 1986.

In addition to these initiatives the extension coordinator also helped to organize and participated in several workshops and seminars:

-In cooperation with survey staff from the Middlesex County Project, a presentation was made at a soil conservation day in Middlesex during which the new preliminary maps for the area were introduced. Part of the presentation included the discussion of soil properties and the interpretation of agricultural capability as demonstrated by profile features as exposed in a soil pit.

-A field course to teach forest staff about the relationships between soils and silviculture was organized in Brant County and put on in cooperation with a forest soil specialist with the Institute. This course was conducted as part of the Conservation Authority's annual workshop.

-A soil and silviculture workshop hosted by the Institute assisted members of the Six Nations Reserve in their efforts to learn to describe soils for forest management purposes.

-The initial contact was also made for a seminar in the Regional Municipality of Haldimand-Norfolk. This seminar is discussed in more detail below.

Other Extension Activities In 1987

Additional extension activities by the Institute in 1987 included:

-A seminar was hosted by the Institute in the Regional Municipality of Haldimand-Norfolk. It focused on the soil map and report as a valuable reference and aimed to make users aware of the information which could be extracted from them. A very positive response was received from those who participated in the seminar and more events of this type are planned.

-A presentation to the land use specialists of OMAF's Foodland Preservation Branch on the current status of the Canada Land Inventory agricultural capability interpretations in Ontario.

-A meeting held with the OMAF assistant agricultural representative and the OMAF land use specialist in Peterborough County. This meeting was held in order to introduce an improved and updated C.L.I. interpretive table for the area which was requested due to problems encountered with the existing level of information. A much larger presentation is being planned in the area early in 1988 to introduce the changes to members of the planning community at large.

-A presentation made to the managers of the Farm Credit Corporation. This user group is examining the application of soil survey maps and interpretations to the farm assessment procedure which their field staff use. It is anticipated that soil survey information will become an even more important input to this process in the near future.

An Ecology class near Morriston. October, 1936.

-A two day workshop held at the University of Guelph entitled, "Approaches To The Evaluation Of Forest Productivity In Ontario". This event was attended by approximately sixty people from government, industry, and universities in Canada and the United States.

-As part of a Timber Certificate Course, OIP staff assisted OMNR forest technical staff to learn how to describe in the field those soil properties important for matching tree species to site conditions.

-During a SOARS (Survey of Artificially Regenerated Sites) workshop OIP staff assisted in the training of OMNR casual staff to identify forest site properties in the field.

-In OMNR's Northwestern Region, OIP staff assisted in training forest staff in the identification of soil and vegetation properties of sites in Northwestern Ontario.

-Together with forest research staff at the Petawawa National Forestry Institute a workshop was hosted for OMNR staff working in the Algonquin Region focusing on the relationship between site and silviculture in the management of White and Red Pine.

-A soil and silviculture workshop for the Central and Southwestern Regions was hosted cooperatively by OIP and OMNR staff for OMNR and Conservation Authority forest staff.

Technical Advisory Services in 1987

The OIP, in addition to providing general extension services to identified user groups, also addresses specific requests for technical advice on soil and resource management related issues.

One of the primary demands for technical advisory services comes from OMAF's Foodland Preservation Branch. In many instances proposed zoning by-law amendments, severance applications, gravel pit license applications and other decisions of a site specific nature call into question the CLI agricultural capability rating for given areas. Often these issues can culminate in an Ontario Municipal Board (OMB) hearing. In these cases the pedologists at the Institute are called upon to review the soil survey and interpretive information for the area and do an on-site assessment of the agricultural capability. This is carried out in order to confirm that continued agricultural use of a given area is something that the Ministry wishes to defend. Often, this on-site assessment is paralleled by private consultants working for the parties interested in the zoning change. In cases where an OMB hearing is required, OIP pedologists are required to give expert testimony on the soil and landscape characteristics observed at the site and the implications these have for agricultural capability. In 1987 the Institute was asked to give input on seven issues of this type.

Other technical advisory services provided in 1987 include:

-The production of detailed soil inventories of the Agriculture Canada pesticide research farm in Middlesex County and of the University of Guelph Eramosa Research Station farm.

-A presentation on soil information given to a group working on a micro-climatic study of the Fonthill Kame.

-A presentation given to a group of Waterloo Region councilors on how the soils of the Clyde area were mapped and classified. This was done in order to assist in resolving a zoning dispute.

-Soil assessment related to the location of landfill sites in Renfrew and Lanark Counties in Eastern Ontario.

-The involvement of soil survey personnel from the Elgin and Middlesex County Projects in the soil assessment work being carried out by Ontario Hydro for their utility corridor route selection.

-Meetings held with members of the Niagara planning community regarding the interpretation of soil information for suitability for grapes.

-Consultation to the Ontario Ministry of Natural Resources on soil interpretations for forest management, the interpretation of existing land resource inventories for productivity evaluation, the designing of soil surveys of forested lands, and the incorporation of soil and land resource information in future geographic information system applications.

-A variety of smaller requests and questions were answered by pedologists on a daily basis as they were received.

SUPPORT SERVICES

Introduction

In support of the Inventory objective of the OIP there exists three support facilities. These are the soil characterization lab, the computer facilities and the cartographic studio. Each of these support services is involved with a different aspect of soil inventory projects.

The soil characterization lab provides laboratory analysis of samples taken by pedologists in the field. This analytical data allows the surveyor to characterize the properties of soils being mapped.

Analytical data along with landscape and profile information is organized and manipulated within the computer facilities of the OIP. Sorting and statistical analysis of databases aids in the development of a modal concept for mapped soils, sheds light on the range of variability around this modal concept and helps identify relationships between soil characteristics and landscapes. In addition to handling soil data the computer lab also incorporates a geographic information system. This system allows the storage of maps in the form of digital computer data bases along with attribute files containing information about areas delineated on the maps. In short, this allows the pedologists to get computer analysis and interpretation of information in map form.

The cartographic services of the OIP are located in the Land Resource Science Department of the University of Guelph. The cartographic staff play a key role in transfiguring draft copies of maps and reports into a form suitable for publication. The cartographic services also contribute toward the extension objective of the OIP by helping to develop displays and resource material for extension activities and publications.

The following reports give some additional information on these support services and their activities in 1987.

Computer Operations

C. Fitzgibbon

Over the past few years the OIP has acquired a variety of computer equipment ranging from microcomputers to digitizing tablets to plotters, along with a variety of software. The availability of this equipment has allowed a number of exciting innovations for the soil survey. Indeed the focus for the computer lab in 1987 was to make computer operations an integral part of the soil survey with the aim of enhancing all parts of the survey process.

New field data collection cards were designed to improve and standardize the field recording of soil data and to allow more efficient data entry in the computer lab.

The structure and relationships of the computerized soil data files were revised and better integrated to allow improved data entry and analysis in the computer lab and to provide easier access and output of information to the soil survey staff. New data entry programs were also designed to reflect the new data file structures. Also, a reporting system providing ongoing records of number of sites sampled and details of the data collected was developed. These records are used by the surveyors for monitoring progression of the mapping program and sampling intensity.

A computerized system was also developed to allow in-house production of Volume Two of the soil survey report. Volume Two contains the detailed morphological, physical and chemical descriptions of soils typical of the area included in the report. The detailed soil data are extracted from the OIP soil database system, merged with profile descriptions and then transferred to a desktop publishing system which is available in the cartographic studio at the University of Guelph. This system promises to allow more rapid publication of the soil survey data while maintaining a high quality of presentation.

The Institute has recently acquired new digitizing software which will enhance and greatly accelerate the digitizing of soil maps in preparation for publication. The new software also provides a greater capability for the production of computer generated interpretive maps.

All of these initiatives in the computer operations at OIP have provided for improvements in the soil survey operations. It is anticipated that the next year will continue to provide new initiatives and improved operation of the soil survey.

OIP Soil Characterization Laboratory

B. K. Hohner

The Soil Characterization Laboratory of the Ontario Institute of Pedology (OIP), is located in the Department of Land Resource Science, at the University of Guelph. It provides soil analytical services for members of the Institute who are involved in soil resource inventories and research in soil genesis, morphology, classification, characterization and interpreta-

tion of Ontario soils.

In 1987, the Soil Characterization Lab provided soil analyses for the following projects:

Project	No. of Samples Analyzed
Algonquin Site Program	277
Tillage 2000	362
Brant Survey	82
Elgin Survey	1051
Middlesex Survey	333
OIP Research	238

The OIP Soil Characterization lab utilizes a computerized data management system to provide an efficient flow of soils data between the lab and the soil surveyors and researchers.

The lab strives to maintain the highest quality in its analyses. Quality control procedures, intralaboratory testing, the use of standard methods as established by the Land Resource Research Centre in Ottawa, and the use of soil standards help the lab to maintain precision and accuracy.

Laboratory analysis of soils. Circa 1940's (?).

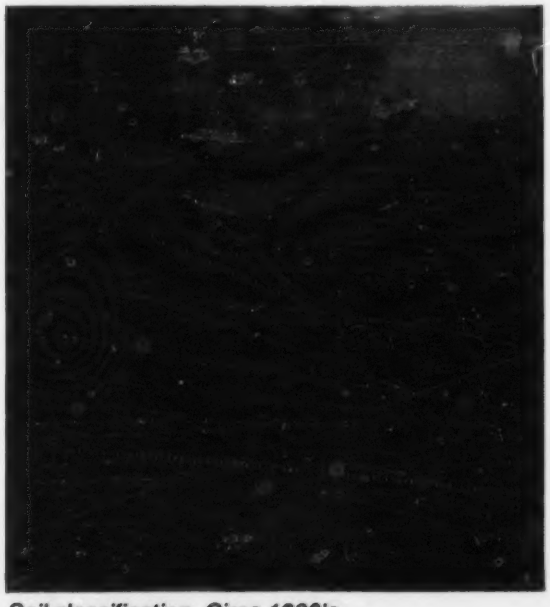
Cartography Studio

D. Irvine

The cartography office is located at the University of Guelph, Department of Land Resource Science. It is here that maps and publications are designed, layed-out and made camera ready. The county soil maps are then digitized in the computer facilities of the Institute prior to being transferred in digital form to the Land Resource Research Institute, Ottawa for colour printing and final publication.

As mentioned last year a desk-top publishing software package was purchased. This, along with a sophisticated graphic design software package are now in extensive use. Using this new software, Volume Two of the County Soil Reports, and numerous other publications are now being done entirely in-house. This annual report is an example of what can be accomplished in-house with desk-top publishing.

Due to lag time between completion of county surveys and the availability of this information from Ottawa to the public, we now publish in-house typeset quality preliminary maps and interpretive publications to meet public demand for survey information. This has been made possible by computer generated graphics.



Soil classification. Circa 1930's.

1987 PUBLICATIONS

Soil Inventory Projects

Published Preliminary Maps:

Hagerty, T. P., T. E. Hilborn 1987 "Preliminary Soils of Middlesex County (Northwestern Portion), Southern Ontario" Ontario Institute of Pedology Preliminary Map. P.M. 33, scale 1:50,000.

Hagerty, T. P., T. E. Hilborn 1987 "Preliminary Soils of Middlesex County (Southern Portion), Southern Ontario" Ontario Institute of Pedology Preliminary Map P.M. 34, scale 1:50,000.

Acton, C. J. 1987 "Preliminary Soils of South Dumfries Township, Brant County, Southern Ontario" Ontario Institute of Pedology. scale 1:25,000.

Acton, C. J. 1987 "Preliminary Soils of Burford Township, Brant County, Southern Ontario" Ontario Institute of Pedology. scale 1:25,000.

Preliminary Interpretive Publications:

Hagerty, T. P. 1987 "Preliminary Agricultural Soil Capabilities for Common Field Crops in Middlesex County." Ontario Institute of Pedology Publication 87-4.

Ontario Institute of Pedology 1987 "Preliminary Soil Suitability Ratings for Soybeans, White Beans, Spring Canola and Winter Rapeseed in the Niagara Region" Ontario Institute of Pedology Publication 87-1.

Ontario Institute of Pedology 1987 "Preliminary Soil Suitability Ratings for Vegetable Crops in the Niagara Region." Ontario Institute of Pedology Publication 87-2.

Ontario Institute of Pedology 1987 "Updated Agricultural Soil Capabilities for Common Field Crops in the Niagara Region" Ontario Institute of Pedology Publication 87-6.

Ontario Institute of Pedology 1987 "Updated Soil Suitability Ratings for Tree Fruits, Grapes and Small Fruits in the Niagara Region" Ontario Institute of Pedology Publication 87-7.

Ontario Institute of Pedology 1987 "Updated Soil Suitability Ratings for Soybeans, White Beans, Spring Canola and Winter Rapeseed in the Niagara Region" Ontario Institute of Pedology Publication 87-9.

Ontario Institute of Pedology 1987 "Updated Soil Suitability Ratings for Vegetable Crops in the Niagara Region" Ontario Institute of Pedology Publication 87-10.

Ontario Institute of Pedology 1987 "Agricultural Capabilities For Peterborough County" Ontario Institute of Pedology Publication 87-11

Published Final Soil Reports and Maps:

Schut, L. W., E. A. Wilson 1987 "The Soils of the Regional Municipality of Ottawa-Carleton (excluding the Ottawa Urban Fringe)" Vols. 1 & 2, Report No. 58 of the Ontario Institute of Pedology (contains 3 map sheets, scale 1:50,000).

Ontario Institute of Pedology 1987 "Soils of Grimsby-Lincoln. Regional Municipality of Niagara, Ontario." Sheet 2. scale 1:25,000.

Ontario Institute of Pedology 1987 "Soils of St. Catharines and Niagara-on-the-Lake. Regional Municipality of Niagara, Ontario". Sheet 3. scale 1:25,000.

Ontario Institute of Pedology 1987 "Soils of Pelham-Thorold-Welland. Regional Municipality of Niagara, Ontario". Sheet 4. scale 1:25,000.

Ontario Institute of Pedology 1987 "Soils of Niagara Falls. Regional Municipality of Niagara, Ontario". Sheet 5. scale 1:25,000.

Ontario Institute of Pedology 1987 "Soils of Wainfleet. Regional Municipality of Niagara, Ontario." Sheet 6. scale 1:25,000.

Ontario Institute of Pedology 1987 "Soils of Fort Erie-Port Colbourne. Regional Municipality of Niagara, Ontario" Sheet 7. scale 1:25,000.

Northumberland County. Circa 1930's.

General Publications:

McBride, R.A., L. Bober 1987 "Soil Compaction In Ontario: A Susceptibility, Interpretive and Test Procedure" Highlights of Agricultural Research in Ontario. 10(3): pp. 13-16

Ontario Institute of Pedology 1987 "The Ontario Institute of Pedology 1986 Annual Report" T. P. Hagerty (ed.).

Ontario Institute of Pedology 1987 "Index of Soil Surveys In Ontario" M. S. Kingston (ed.).

Contributions to Refereed Journals:

Angers, D.A., B.D. Kay and P.H. Groenevelt 1987 "Compaction Characteristics of a Soil Used for Corn and Bromegrass Production" Soil Sci. Soc. Amer. J. 51: 779-783.

Baffoe, J.K., D.P. Stonehouse and B.D. Kay 1987 "A Methodology for Farm Level Economic Analysis of Soil Erosion Effects Under Alternative Crop Rotational Systems in Ontario" Can. J. Agr. Econ. 35: 55-74.

Baldock, J.A., B.D. Kay, M. Schnitzer 1987 "Influence of Cropping Treatments on the Monosaccharide Content of the Hydrolysates of a Soil and its Aggregate Fraction" Can. J. Soil Sci. 67: 489-499.

Baldock, J.A. and B.D. Kay 1987 "Influence of Cropping History and Chemical Treatments on the Water-Stable Aggregation of a Silt Loam Soil" Can. J. Soil Sci. 67: 501-511.

Dickinson, W.T., R.P. Rudra and G.J. Wall 1987 "Indentification of Soil Erosion and Fluvial Sediment Processes" Hydological Processes, Vol. 1, pp. 111-124.

Donald, R.G., B.D. Kay and M.H. Miller 1987 "The Effect of Soil Aggregate Size or Early Shoot and Root Growth on Maize (Zea mays L.)" Plant and Soil 103: 251-259.

Rudra, R.P., W.T. Dickinson, D.J. Clark and G.J. Wall 1987 "GAMES - A Screening Model of Soil Erosion and Fluvial Sedimentation in Agricultural Watersheds" Can. Wat. Res. Jour. Vol. 11 (4).

Shipitalo, M.J. and R. Protz 1987 "Comparison of Morphology and Porosity of a Soil Under Conventional and Zero Tillage" Can. J. of Soil Sci. 67: 445-456.

Tossell, R.W., Dickinson, W.T., Rudra, R.P., and Wall, G.J. 1987 "A Portable Rainfall Simulator" Can. Agric. Eng. 29:155-162.

List of Papers Presented:

McBride, R.A. and L. Bober 1987 "An Examination of Soil Consistency-Compressibility Relationships" Presented to the Can. Soc. Soil Sci., Ottawa, August,1987.

Protz, R. and J. Fischer 1987 "Evaluation of Airborne MEIS-II and Landsat Thematic Mapper Data For Detailed Soil Surveys" 11th Can. Remote Sensing Symposium. Waterloo, Ontario. June 1987.

Protz. R. and A. Jano 1987 "Comparison of Landsat MSS and TM Data for Soil Surveys in the Northern Ontario Lowlands" 11th Can. Remote Sensing Symposium. Waterloo, Ontario. June 1987.

Jones, R.K. 1987 "Site classification in Ontario: Review, Evaluation and Opportunities For Integration With Process Models" Presented at IEA/FEA Project CPC 10 Workshop on "Predicting Consequences of Intensive Forest Harvesting on Long Term Productivity by Site Classification", October 2-9, 1987, Baruch Forest Science Institute of Clemson University, Georgetown, South Carolina, U.S.A.